In The United States Court of Federal Claims

No. 00-705C

(Filed Under Seal: December 23, 2005)

(Filed: January 31, 2006)[1]

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THE BOEING COMPANY,	*	Trial; Alleged infringement of patent by
	*	NASA in developing super lightweight
Plaintiff,	*	external tank for Space Shuttle; Claim
	*	construction; *Phillips*; "predetermined
v.	*	underaged strength level"; "less than 300°
	*	F"; Validity of patent; Anticipation;
THE UNITED STATES,	*	Obviousness; *Graham* factors; Terminal
	*	Disclaimer; Infringement; Addition of silver;
Defendant.	*	Temperature; External tank infringes Boeing
	*	patent; No license.
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OPINION

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Arthur M. Lieberman, *Keith D. Nowak* and *Richard J. Conway*, Dickstein, Shapiro, Morin & Oshinsky, LLP, for plaintiff.

Ken B. Barrett, United States Department of Justice, Washington, D.C., with whom was Assistant Attorney General *Peter D. Keisler*, for defendant.

ALLEGRA, Judge:

This patent case is before the court following an extensive trial in Washington, D.C.

During initial planning, the angle of inclination of the orbit of what would become the International Space Station – its orbit relative to the equator – was set at 28.5 degrees, to coincide with the latitude of the National Aeronautic and Space Administration (NASA) launch center at Cape Canaveral, Florida. This was designed to give the Space Shuttle maximum momentum (rotational throw) as it left the earth's gravity, thereby maximizing its payload delivery capability for space station missions. In the late 1980s and early 1990s, with the Cold War waning, NASA became increasingly interested in building the station in partnership with the Russian Federal

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[1] An unredacted version of this opinion was issued under seal on December 23, 2005. The opinion issued today incorporates the parties' jointly proposed redactions and corrects some minor typographical errors. This redacted material is represented by brackets [ ].

Space Agency. But, for Russian spacecrafts to reach the station from their launching pads at the Baikonur Cosmodrome in Kazakhstan, the planned inclination of the station's orbit had to be adjusted to 51.6 degrees. This would have significantly reduced the Shuttle's payload delivery capability for station missions – from 48,000 pounds to 35,000 pounds – which, in turn, would have delayed deployment of the various modules of the massive station. To prevent this, among other things, the external tank of the Shuttle was redesigned to be 7,500 pounds lighter, with this weight savings generating an almost pound-for-pound increase in the Shuttle's payload capability. Much of the weight reduction came from the use of a new aluminum-lithium alloy, Alloy 2195, which was weldable, 30 percent stronger, and five percent less dense than the aluminum alloy previously used in the external tank.

But, Alloy 2195, as well as the products fabricated therefrom, resulted from processes that the Boeing Company (Boeing) contends violated certain claims in its U.S. Patent No. 4,840,682 (the '682 patent). In this lawsuit, Boeing seeks compensation from the United States, under 28 U.S.C. § 1498(a), for the alleged unlawful use by NASA of this aluminum-lithium alloy in the redesigned external fuel tank of the Space Shuttle. Defendant remonstrates that the relevant claims of the '682 patent are either invalid due to anticipation and obviousness in light of the prior art, or limited by a terminal disclaimer. It further contends that, even if those claims are valid, there is no infringement here because, *inter alia*, the content of Alloy 2195 and the process used to age the panels of the external fuel tank are different than what is claimed in the '682 patent. Finally, it asserts NASA had a license to employ the claimed invention.

I. FACT FINDINGS

Based on the record, including the parties' stipulations, the court finds as follows:

A. Basic Metallurgy as it Relates to Aluminum

Before plunging into the relationship between the '682 patent and the development and construction of the external fuel tank of the Space Shuttle, it is helpful to begin, as the parties did, with some basic metallurgy concepts, particularly, as they apply to aluminum alloys, and, especially, as to aluminum-lithium alloys.

1. Metallurgy Principles

An alloy is a substance with metallic properties, composed of two or more chemical elements, of which at least one is a metal. The properties of alloys depend upon their structural characteristics, which can be modified by changing the processing of the alloy, the composition thereof, or both. Among the properties that may describe a particular alloy are –

- **Tensile strength**, or ultimate strength, which refers to the force necessary to break a test specimen when subjected to stretching. Tensile strength is ordinarily stated in "Ksi" – thousands of pounds per square inch.

- **Ductility,** which is a measure of the material's ability to undergo appreciable plastic deformation before fracture. Elongation is a measure of ductility.

- **Yield strength,** which refers to the strength of a material where permanent and non-recoverable, or plastic, deformation occurs.

- **Fracture toughness,** which is a measure of the resistance a material has to the extension of a crack, and is indicative of a material's resistance to fracture when a crack is present.[2]

- **Hardness,** which usually refers to the resistance to indentation and which, because it is a measure of plastic deformation, correlates with strength.

Commercial alloy products may be produced through castings, by pouring molten alloy directly into a mold or die cavity of the required shape. They also may be wrought, where an alloy initially cast as an ingot or billet is subjected to mechanical working by such processes as rolling, extruding, forging, or drawing, to yield semifinished products from which end-use products are then fabricated.

Wrought alloys can achieve a higher strength through temperature treatments, known as "aging." Aging changes one or more properties of an alloy without altering its chemical composition. Such heat treatments generally are low-temperature (*e.g.*, 240-375° F), long-term processes (*e.g.*, 5-48 hours). Heat-treatable wrought alloys obtain strength by the homogenous distribution of fine particles – called grains – that precipitate during the aging process. Age hardening may occur at room temperature over a few days, *i.e.*, "natural aging," or more rapidly at some desirable temperature in an aging oven, *i.e.*, "artificial aging." Alloys may be: (i) underaged, that is, not aged sufficiently to obtain the maximum value for a certain property, such as hardness or strength, at a particular aging temperature; (ii) peak aged, that is, aged sufficiently to obtain a maximum value for a certain property, such as hardness or strength, at a particular aging temperature; or (iii) overaged, that is, aged longer than the time necessary to obtain the maximum value for a certain property, such as hardness or strength, at a particular aging temperature. These aging levels can be depicted graphically as curves on charts with time and temperature axes. Underaging may be obtained by aging for shorter times or at lower temperatures than normally used to obtain a peak value.

Artificial aging occurs in commercial ovens set at a chosen temperature (the set point). All commercial ovens encounter some fluctuation in temperature because once the set point is met, the blowers or the burners in the furnace turn off, only to revive when the temperature drops

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[2] The Fracture Toughness Ratio (FTR) is the alloy's toughness at cryogenic temperature divided by its toughness at room temperature. Cryogenic temperatures are very cold, on the order of hundreds of degrees Fahrenheit below zero.

a certain unacceptable level below the set point. This process iterates repeatedly about the set point, creating slight fluctuations of temperature. A so-called "working sensor" measures the response in the oven as a function of time or the overall temperature of the oven. By comparison, "thermocouples" measure the temperature on the objects being heated and are placed at key prescribed locations directly on those objects. In the industry, one may refer to the set point as a shorthand for the aging temperature, but ordinarily, in the specifications for aging treatments, the temperature is described in a way, such as a plus or minus range, that accommodates the variation that occurs in industrial ovens.

2. Aluminum Alloys

Aluminum has widespread use in the aerospace industry, not only because of its low density, but because it can be strengthened significantly through judicious alloying, as well as thermal and mechanical processing. Most aluminum alloys contain 90 to 96 percent aluminum, with the remainder comprising one or more elements added to provide a specific combination of properties and characteristics. The addition of these alloying elements is done, for example, to decrease density and increase fracture toughness. Such alloys may be produced by two different methods: (i) ingot metallurgy, for which the molten metal is cast into very large ingots, usually by a method called "direct chill (DC) casting;" and (ii) powder metallurgy, for which powder is produced by a process of rapid solidification or mechanical alloying.

Lithium has been included in aluminum alloys since at least the early 1920s. As the lightest metallic element, its addition to aluminum results in a lightweight alloy that is potentially useful on aircraft because it yields lightweight structures that permit higher payload capacity and enhance general performance. Historically, however, the reduction in density accomplished by adding lithium to aluminum came with a cost – undesirable reductions in ductility and fracture toughness.[3] At least some studies attributed these reductions to the presence of sodium and potassium (and in some cases, calcium, hydrogen and sulfur), presumed present as impurities in the lithium metal used in preparing the alloy. To combat this problem, new alloys and processing techniques were developed to improve the aluminum-lithium alloys' properties, particularly strength and fracture toughness. In some instances, alloys are now solution heat-treated, cold-worked and then artificially aged – a process referred to as a T8 temper. In others, the addition of magnesium, as well as zinc, copper, or silicon, increases the strength of aluminum alloys.

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[3] Around 1954, fracture toughness became a particular concern for aircraft manufactures, after a series of airplane crashes were caused, in part, by poor fracture toughness. In 1978, certification of new aircraft required that manufacturers demonstrate that cracks would be detected prior to their reaching the critical length associated with catastrophic failure. This is why airplane pilots or other airline personnel are seen walking around the plane prior to take off – they are looking for visible cracks.

B. The Development of the Invention

As will be seen, it is important to note what Boeing knew and when it knew it.

1. Early Progress

A September 1973, report prepared by Boeing for the Air Force Materials Laboratory, entitled "Program to Improve the Fracture Toughness and Fatigue Resistance of Aluminum Sheet and Plate for Airframe Applications,"[4] suggests that underaging of the so-called 2000 and 7000 series of aluminum alloys[5] had not been contemplated by Boeing as of that time. The report indicated that Boeing had altered the chemistry of some aluminum-lithium alloys by substituting zirconium for chromium, and by reducing the iron and silicon therein. But, it indicated that research had shown that these alloys suffered from "[l]ow fracture toughness at high strength levels and wide variability in toughness for any given alloy and temper." According to the report, a literature study revealed that the use of underaging treatments for 7000-series alloys should be discouraged because "the material will be more susceptible to stress-corrosion cracking and to intergranular or exfoliation attack."[6] In this regard, the report stressed –

> For the 2000-series alloys, there is very little published information on the effects of thermomechanical treatments or composition variables on the stage II fatigue crack growth rates. Generally, as material is aged from the naturally aged T4 or T3 condition to the T6 to T8 condition, strength goes up and fatigue crack propagation rates increase for a given [strength] level.

While Boeing indicated that lower aging treatments, at 280° F for the 2000 series, and at 325° F for the 7000 series, showed promise in improving fracture toughness, it was unsure how these relatively

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[4] This report stems from a government contract (No. F33615-72-C-1649) Boeing had with the United States Air Force in the early 1970s. In the instant suit, the government initially argued that the invention fell within the scope of this contract, but it ultimately failed to advance this argument at trial or in its post-trial briefs.

[5] A system of four-digit numerical designations is used to identify wrought aluminum alloys. The first digit indicates the alloying element present in the greatest mean percentage, dividing aluminum alloys into groups. For example, the 2xxx alloy group contains a greater mean percentage of copper than other alloying elements, while the 7xxx group contains a greater mean percentage of zinc than other alloying elements. The second digit indicates modifications of the original alloy or impurity limits, and the last two digits identify the specific aluminum alloy.

[6] Generally, "exfoliation" is corrosion that proceeds laterally from the sites of initiation along planes parallel to the surface, generally at grain boundaries or coating interfaces, forming corrosion products that force metal or coating away from the body of the material, giving rise to an undesirable layered appearance.

low aging temperatures would affect strength levels. In addition, Boeing reported that it had not yet developed a preferred aging time for this process (indicating that several hundred hours could be necessary), concomitantly noting concerns that low temperature aging might result in problems with exfoliation resistance.

This state of affairs began to change in the Fall of 1980. On September 8, 1980, Dr. William Quist of Boeing, one of the named inventors in the '682 patent, contacted Dr. Colin Baker of British Aluminum Company (BACo) to solicit the latter company's participation in a program to develop aluminum-lithium alloys for aircraft applications. On October 27, 1980, BACo responded with a proposal indicating that "[t]he influence of composition and thermo-mechanical processing on the microstructure and the possibility of overcoming property deficiencies in particular toughness, will be the major objective of this work." Subsequently, Boeing established an independent research and development (IR&D) program that focused generally on improving aluminum alloys, and specifically, on the development of lithium-containing aluminum alloys. Documentation for this program acknowledged the fracture toughness difficulties that previously had haunted aluminum-lithium alloys, and stated that those problems "have been variously attributed to (1) impurities, (2) persistent slip bands and associated stress concentrations at grain boundaries, and (3) the . . . oxide layer on powder particles." This led the Boeing team to conclude that "[t]hese alloys will be examined in several conditions of aging and thermomechanical treatments (TMT) that will either alter grain size and/or strengthen the alloy by methods other than precipitation hardening." In 1981, Boeing allocated $122,000 for the program, assigning it the internal tracking number BCAC3315.[7] Early data sheets for this project indicated that Boeing was pursuing zirconium levels comparable to those eventually listed in the '682 patent, with at least one alloy studied being within the exact compositional range of the patent.

In 1981, Dr. G. Hori Narayanan was transferred to the commercial airplane division and started working with Dr. Quist. On March 10, 1981, Drs. Narayanan and Quist, as well as others, received authorization to work with BACo "to develop one or more low density lithium containing aluminum base alloys that will be suitable for aircraft structural applications." The authorization document stated that "[e]xperimental aluminum-lithium-type alloys will be made by both ingot and powder metallurgy during this investigation, since it has not been established which of these methods is to be preferred." Of the eight aluminum-lithium alloy compositions set out in this report, one fell within the compositional ranges of the '682 patent and five others would have, but for their lack of zirconium.

Over the next year or so, Boeing worked with Aloca and Martin Marietta to develop alloys. During the second half of 1981, Boeing received eleven different alloys from BACo, which were evaluated for strength and toughness. Of the aluminum-lithium alloys that Boeing

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[7] Until the end of 1982, the project had a 3315 code, and then in 1983, the aluminum-lithium activity was separated from other aluminum projects and a new code was used: 3327. Some of the projects under the 3315 designation were not proprietary and were reported outside the company, whereas the project under the 3327 code was proprietary.

considered for study in 1981, two had zirconium levels of 0.10 wt % and 0.15 wt %, one had a level of 0.25 wt %, and five contained no zirconium. BACo had already learned that certain levels of zirconium produced a desirable microstructure for aluminum-lithium alloys. By October of 1981, the inventors also had learned to limit the lithium percentage to 3.8 wt.

Boeing continued to conduct aging treatments on alloys that showed promise in terms of strength and toughness. In the remainder of 1981 and through the first half of 1982, a study of the eleven BACo alloys showed some benefit to employing lower aging temperatures than what previously had been standard practice. To verify this, Boeing engineers aged the alloys using a range of aging temperatures, at 25 degree increments, from 250° to 350° F. Some of the alloys tested were within the composition set by the ‘682 patent. Data sheets from this period exhibit progress. One of the heat treatments employed in the second half of 1981 was for the aluminum-lithium alloy BA 546, which was aged at 275° F for 72 hours. At least one data sheet showed that, by this time, the Boeing engineers had also learned to limit the presence of chromium.

Throughout 1982, plaintiff expanded its effort to develop aluminum-lithium alloys as part of its IR&D program, toward that end obtaining alloys from four additional suppliers. After realizing that none of the eleven BACo alloys were showing the right range of properties, Drs. Narayanan and Quist initiated a phase two study, wherein Boeing modified the chemistry of the aluminum-lithium alloys by varying the amounts of the alloying elements, including not only lithium, but also copper, magnesium and zirconium, in an effort to get the right microstructure and combination of properties. As a result, on May 10, 1982, Boeing ordered a modified version of an alloy denominated B-18, which, unlike a prior version, contained zirconium, bringing it within the compositional range of the ‘682 patent.

Shortly thereafter, around July of 1982, Mr. R. Eugene Curtis joined the Boeing Materials Technological Team. At this time, he designed an experiment to evaluate the aging process, further using aging temperatures from 250° to 350° F, with 25 degree intervals. Mr. Curtis decided to use low temperature underaging as a result of his experience with titanium alloys, in particular using aging temperatures (for aluminum-lithium alloys) of less than 300° F, much lower than the conventional aging temperatures of 325° and 350° F. Through this testing, the inventors generated aging curves from which they picked several candidate temperature/time combinations and generated strength and toughness data. On October 4, 1982, Mr. Curtis directed that a sheet of the B-18 alloy be aged for various times at temperatures of 350°, 325°, 305°, 275°, and 250 ° F, and then subjected to various tests, including tests of fracture toughness.

2. Boeing’s Contract with the Air Force

Meanwhile, on May 5, 1981, the United States Air Force (the Air Force) issued a Request for Proposal (RFP) seeking proposals to advance the methods of powder metallurgy (P/M) in the development of aluminum-lithium alloys. Around June 18, 1981, Boeing responded to the RFP, proposing, via “rapid solidification technology” and a “powder metallurgical approach,” to “incorporate higher amount[s] of lithium” in aluminum-lithium alloys and thereby reduce their

density. Boeing further indicated that it would use several innovative metallurgical approaches to solve the ductility and toughness problems associated with high-lithium alloys.

On December 23, 1981, Boeing and the Air Force signed a research and development contract, No. F33615-81-C-5053 (the 5053 contract), entitled Low Density Aluminum Alloy Development, which took effect January 4, 1982. The initial funding for this contract was $1,154,240, although an additional $200,000 was added later. According to its terms, the objective of the contract was "[t]o develop a family of powder aluminum alloys with significantly lower density and substantially higher specific modulus and strength than existing 7000-series aluminum alloys," with the properties of such alloys to "be tailored for specific classes of aerospace structural applications." While several provisions emphasized that the primary focus of the contract was the development of powder alloys, one provision indicated that "[a] portion of the program may be devoted to the investigation of ingot alloys to determine if property goals achieved with powder can be achieved by ingot metallurgy."[8] The contract was to have three phases, described at one point therein, as follows:

> Phase I shall include organization of a contract team, preliminary application and goal assessment, and a state-of-the-art review. Phase II will address the development of alloys and processing methodologies meeting the goals defined in Phase I. Phase III will be a component design study utilizing the low density aluminum properties achieved in Phase II to assess potential payoff in Air Force airframe applications.

Other parts of the contract indicated that from three to fifteen alloy systems or processes were to be selected for development. Essentially, under these phases, Boeing was to extrapolate the benefits that would be received by the Air Force if the best of the alloy systems and processes studied were employed in the structural components of various aircraft.

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[8] In this regard, one clause of the contract further explained –

> Specific property goals will reflect particular classes of application requirements identified within the program. Initial target properties, likely to result in distinct alloy chemistries will include: 10% reduction in density, 30% increase in specific modulus, 20% increase in specific strength, and elevated temperature capability accompanied by reduced alloy density. The primary thrusts of the program will be alloy development, application studies, and goal assessment; however, relevant issues such as the effectiveness of various powder types, the effects of powder production and handling environment, and the development of a processing model to define the necessary requirements for achieving a 100% dense, high integrity, final product may also be addressed.

Dr. Narayanan summarized his understanding of these provisions of the contract, testifying – "We did include ingot metallurgy alloys in our program as a baseline for comparison . . . to see if the properties that are achieved by powder can be achieved via ingot metallurgy."

The contract incorporated, by reference, the Patents Right Clause of DAR 7-302.23(b) (Jul. 1981), which provided rules with respect to "Subject Inventions," defined as "any invention or discovery of the Contractor conceived or first actually reduced to practice in the course of or under this contract." With respect to such "Subject Invention[s] to which the Contractor retains principal or exclusive rights," paragraph (c) of the clause stated that the contractor "hereby grants to the Government a nonexclusive, nontransferable, paid-up license to make, use, and sell each Subject Invention throughout the world by or on behalf of the Government of the United States (including any Government agency) . . . ." This paragraph, however, continued that "[n]othing contained in this paragraph (c) shall be deemed to grant to the Government any rights with respect to any invention other than a Subject Invention." Paragraph (e) of the clause further provided that "[t]he Contractor shall establish and maintain active and effective procedures to assure that Subject Inventions are promptly identified and timely disclosed." Under paragraph (f), the Contractor forfeited to the United States "all rights in any Subject Invention" if it did not timely comply with the disclosure requirements of the contract. Finally, paragraph (i) of the clause required that provisions similar to those in the patent rights clause be contained in all subcontracts awarded under the contract.

Dr. Terence Ronald was the Air Force project engineer for the 5053 contract. In addition, two of the inventors involved in the '682 patent were involved in the 5053 contract for Boeing, namely, Drs. William Quist and Hari Narayanan, who were responsible for the technical activities of the contract on behalf of Boeing. The other inventor of the '682 patent, Mr. Eugene Curtis, had nothing to do with the 5053 contract. As part of the contract and as "prime contractor," Boeing assembled a team of subcontractors that included Northrop Corporation, Georgia Institute of Technology, Kaiser Aluminum Center for Technology, Pratt & Whitney Aircraft Government Products Division, and International Nickel Company (INCO) Research and Development Center. Boeing executed formal subcontracting agreements with each of these team members, essentially agreeing to split the $1.35 million under the contract six ways, spread over a three-year period.[9]

The 5053 contract required Boeing to submit periodic reports to the Air Force, including technical reports and funding status reports. The first interim technical report, which covered the

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[9] In responding to the draft request for proposals for this contract, Boeing had previously expressed concerns to the Air Force that the contract was inadequately funded, stating in a February 5, 1981, letter, that –

> Another area of concern is that the funding level allocated for this program may be insufficient to achieve all the planned objectives. The basis for this concern is the actual costs incurred in our recent highly successful alloy development program which involved several participants. This program was conceived on the basis of known chemistry vs property relationships, utilized existing ingot technology, and therefore did not involve many unknowns. This is in contrast to the present program that requires more extensive team participation and the utilization of the less developed Al-Li alloy and P/M technology state-of-the-art.

period from January to June of 1982, discussed the results of a massive state-of-the-art literature survey that was conducted on aluminum-lithium alloy development, focusing specifically on papers relating to improving the fracture toughness and ductility of such alloys. The survey led the contractors to focus on the development of compositions that were infeasible with the conventional ingot metallurgy (I/M) approaches, and to emphasize processing approaches unique to powder metallurgy (P/M) alloys. A significant portion of the report discussed past approaches to solve the fracture toughness deficiency of aluminum-lithium alloys, noting that "[s]everal recent investigations tried to improve the ductility and fracture toughness of Al-Li alloys without sacrificing high strength characteristics." In conclusion, the authors noted that these processes had "limited success" and that they often were unsuccessful "because the conventional I/M approach used was unsuitable."[10] As a result of this study, 12 first iteration aluminum-lithium alloys, representing 3 different production methods, were identified for use in the 5053 contract – seven rapidly solidified (R.S.) powder alloys, three mechanically alloyed (M.A.) powder alloys, and two "state-of-the-art" ingot alloys.[11]

The second interim report, covering July through December of 1982, included testing results of the ten P/M alloys, revealing that none of them exhibited acceptable levels of the combination of strength, ductility, and toughness required for use in aircraft applications. Aging studies resulted in charts comparing the hardness achieved for the P/M alloys at different aging treatments at less than peak strength, allowing researchers to determine the treatment(s) that would result in the "highest peak hardness." Based on "several recent investigations" by third-parties which demonstrated that "significant improvements in the fracture toughness and ductility of Al-Li alloys can be achieved with small sacrifices in strength via underaging treatments, two underaged tempers were selected" for further testing. Other charts in the report compared conductivity and hardness under different aging treatments for five different P/M alloys, but none of these compared fracture toughness at a constant strength. The failure of the P/M alloys was

[10] In a monthly status report for May of 1982, plaintiff included a paper presented at the High Performance P/M Aluminum Alloy session of the American Institute of Mining, Metallurgy, and Petroleum Engineers annual meeting in February, 1982, from Dr. Narayanan and two others from companies involved in the contract, entitled "The Heat Treatment, Microstructure and Mechanical Property Correlation in Al-Li-Cu and Al-Li-Mg P/M alloys." In this paper, the authors advised that "underaging treatments can be used as a satisfactory approach to improve the ductility of Al-Li type alloys with only small sacrifices in strength." However, the contractors were looking at aging treatments for previously developed P/M alloys, and did not compare fracture toughness versus underaging temperature at a constant strength.

[11] The ten powder alloys identified were to be produced for testing under the 5053 contract, and none were within the compositional range of the '682 patent. The two ingot alloys were "state-of-the-art," meaning they had already been developed. According to the report, the ingot alloys were included "to compare the best state-of-the-art ingot alloys with the RSR [rapid solidification rate] P/M materials developed during the program," with the understanding that the "program could incorporate ingot alloy development at a later date."

attributed to process deficiencies during powder concentration and extrusion, resulting in "undesirable microstructural characteristics," "compositional inhomogeneities," and poor bonding. As a result, the report identified the need to develop new controls and processes for both the composition and microstructure of these P/M alloys.

The third interim report, which covered January through June, 1983, included results of preliminary testing on the two I/M baseline alloys, finding deficiencies in fracture toughness and strength that might be remedied via "further refinements in chemical composition and in heat-treatment practices." Aging tests were performed on the I/M alloys, evaluating ductility and toughness at different degrees of underaging. A chart plotting curves of hardness versus time under different aging treatments was again produced, but no analysis was performed of fracture toughness versus aging temperature at a constant strength. In addition, a new P/M alloy produced through an improved "melt-spinning" process was added to the existing alloys being tested, and showed marked improvement over the earlier R.S. and M.A. powder alloys. The decision was made to abandon testing on the first iteration P/M alloys as currently produced, and to focus on developing new process and manufacturing techniques to create more suitable powder alloys.[12]

The fourth interim report, covering July through December of 1983, sought to address the consolidation and fabrication issues resulting in poor performance from the powder alloys. The changes proposed in this report included optimizing the atomization process to improve the microstructure and composition of the alloy powder, and developing a new consolidation/ extrusion process to minimize microstructure degradation. Further testing on the I/M alloys showed that they were still short of the three property goals established for the program, but an investigation was begun to determine whether the addition of germanium (up to 0.2 wt % max) to the ingot alloys would increase the alloys' strength and toughness properties. The report noted that industry advances in ingot technology had made their use in aerospace applications a reality, and that "the level of effort to be devoted to I/M alloy evaluation and development" was discussed at the third semiannual contract review meeting on November 10, 1983. It was determined that research should remain "focus[ed] on the development of P/M alloys that will surpass the new-generation I/M Al-Li alloys, particularly with regard to the density reduction goals." The main purpose of the program thus was still "to verify that P/M Al-Li alloys have commercial potential," as it was "impractical for this program to make a substantive contribution to Al-Li ingot technologies." Only "certain unusual developments" in I/M alloys, such as the addition of germanium, would be explored.

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[12] During the midst of this reporting period, the Air Force expressed concerns that Boeing and its partners were not sharing enough information from their accumulated experience. For example, on January 18, 1983, personnel from the Air Force's Structural Metals Branch wrote a letter to Boeing acknowledging a shortage of funds for the 5053 contract, but indicating the Air Force's disappointment with "the level of 'openness'" displayed by Boeing personnel as to their aluminum-lithium alloy IR&D program.

The fifth interim report, which covered January through September of 1984, concluded that despite improvements in process technology, practical difficulties prevented any of the improved R.S. P/M alloys from achieving the microstructural refinements necessary to meet the project goals. All further efforts on these alloys were abandoned. However, the improved M.A. P/M alloys did show "considerable promise of meeting the low density" goals of the program, and testing and evaluation of these alloys and the new "melt-spinning" P/M alloys was to continue. Beryllium-containing aluminum-lithium P/M alloys that were the focus of recent studies by Lockheed also showed the potential for significant density reduction, and therefore "warrant[ed] consideration in the present program." The addition of germanium to the ingot alloys did not conclusively show any significant beneficial effects, but one of the new state-of-the-art base I/M alloys resulting from recent advances in the industry appeared to meet the strength and toughness goals, and nearly met the density reduction goal. The newer ingot alloys, despite several production and properties related problems that remained to be solved, were viewed as having "prospects [that] are quite good for the near-term development and implementation of high strength alloys that are acceptable replacements for the existing aerospace aluminum alloys," and their evaluation was "continued on a limited basis as they represent the baseline comparison for the P/M alloys being developed" in the program.

3. The Patent Takes Final Form

Meanwhile, on October 5, 1982, Mr. Curtis generated a chart for B-18, plotting data at 325° and 350° F, which showed, for example, that if the alloy was aged at 350° F for four hours it would yield a certain strength and toughness combination. This data is identical to the data provided for these temperatures in figure 1 of the patent, a chart that plots the charpy test (for fracture toughness) on the vertical axis and ultimate tensile strength (strength) on the horizontal axis. At the same time, the inventors also generated data for temperatures for 275° and 305° F. The data from these charts is also reflected in figure 1 of the '682 patent. Then, on October 15, 1982, Mr. Curtis charted the results for the full range of aging temperatures, including 250°, 275°, and 305° F.

By November 1, 1982, the inventors started applying their process to all the alloys they received. The heat treatments applied to the alloys were as follows, listing the temperature and then the time: 275° F for 24 hours; 275° F for 72 hours; 250° F for 72 hours; and 300° F for 24 hours. This testing was funded fully by Boeing under its IR&D program. By November 5, 1982, Mr. Curtis had recommended that the B-18 alloy, which fell within what would become the composition of the '682 patent, be aged at 250° F for seventy-two hours. At this time, according to Dr. Narayanan's testimony at trial, "[w]e knew we had a novel process on our hands and that this process was the ability to dramatically improve fracture toughness without sacrificing strength, or at a preselected strength level, we can more than double the fracture toughness."

On December 16, 1982, the data resulting from the November 1 heat treatments was plotted on a chart similar to figure 1 of the '682 patent. On July 22, 1983, the inventors submitted an invention disclosure form to the Boeing patent department, which described the invention as "Low Temperature Aging of Aluminum/Lithium Alloys." Summarizing the essence

of the invention, the inventors set forth a figure, reflecting data recorded on December 10, 1982, that would later be used in the patent, explaining that "[l]ow temperature aging strengthens the [aluminum-lithium] alloys without reducing their toughness significantly compared to aging at high temperatures, resulting in an improved combination of strength and toughness for low temperature aging." At trial, Dr. Narayanan explained that he and the other inventors did not file the disclosure sooner because they were busy testing alloys and "were involved in the Air Force contract." On the same day, the inventors wrote up a chart showing the essence of the invention as applied to three alloys. The invention disclosure was signed by the inventors on December 6, 1983.

The application for the '682 patent was filed with the U.S. Patent and Trademark Office (PTO) on November 21, 1985, and claims the earlier filing date of December 30, 1983, through a parent application that was abandoned (the '227 application) and of which the '682 patent is a continuation-in-part. Silver was not identified as an alloying constituent in the original specification of the '227 application. In the second half of 1986, Dr. Narayanan wrote a summary of the activities that were conducted under the project to improve aluminum-lithium alloys from 1981 to 1986. Therein, he stated that a main accomplishment was to "improve fracture toughness without sacrificing strength" for aluminum-lithium alloys, which is consistent with the '682 patent. Within this summary, Dr. Narayanan focused on the tests that were performed on ten of the hundred or so alloys he and the others tested. Nine of these alloys were within the composition of the '682 patent. The bulk of the heat treatments for these ten alloys were within the time and temperature ranges for the '682 patent. These tests were conducted in 1982 under the IR&D program.

On January 12, 1989, the PTO mailed a Notice of Allowance for the '682 patent. Then, on April 19, 1989, Boeing submitted a terminal disclaimer, disclaiming that terminal portion of the '682 grant that extended beyond the expiration of the earlier to expire of U.S. Patent Nos. 4,603,029 and 4,735,774.[13] The PTO received the terminal disclaimer on April 24, 1989. On June 20, 1989, the '682 patent was issued on an invention by R. Eugene Curtis, William E. Quist (deceased) and G. Hari Narayanan for "Low Temperature Underaging Process for Lithium Bearing Alloys."[14]

[13] U.S. Patent No. 4,735,774 expired on April 10, 1996, for failure to pay the maintenance fee, and U.S. Patent No. 4,603,029 expired on July 29, 1998, for failure to pay the maintenance fee.

[14] As the inventors were all employees of Boeing at the time they made the invention, they were each obliged to assign their invention to Boeing, and did so. The assignment of the '682 Patent to Boeing is recorded in the records of the U.S. Patent and Trademark office. Dr. Narayanan, under an invention agreement, receives one third of 20 percent of any income from the '682 patent received by Boeing.

C. U.S. Patent No. 4,840,682

The ‘682 patent teaches a process for significantly enhancing the combination of strength and fracture toughness properties of aluminum-lithium alloys by underaging the alloys at temperatures ranging from 200° F to below 300° F for relatively long periods of time. The patent consists of seven claims, the latter six of which are dependent, in some fashion, upon the first. That first claim recites as follows:

> A process for improving the fracture toughness of an aluminum-lithium alloy without detracting from the strength of said alloy, said alloy consisting essentially of:

Element	***Amount (wt. %)***
Li [Lithium]	1.0 to 3.2
Mg [Magnesium]	0 to 5.5
Cu [Copper]	0 to 4.5
Zr [Zirconium]	0.08 to 0.15
Mn [Manganese]	0 to 1.2
Fe [Iron]	0.3 max
Si [Silicon]	0.5 max
Zn [Zinc]	0.25 max
Ti [Titanium]	0.15 max
Other trace elements	
Each	0.05 max
Total	0.25 max
Al [Aluminum]	Balance,

> said alloy first being formed into an article, solution heat treated and quenched, said process comprising the step of aging said alloy article to a predetermined underaged strength level at from about 200° F. to less than 300° F.

Claim 7 of the ‘682 patent reads: “The product produced by the process of claim 1,” and is a “product-by-process” claim. Various of the terms in these claims have been construed by the court, either independently or consistent with the parties’ stipulation. *See Boeing Co. v. United States*, 57 Fed. Cl. 22 (2003). Those definitions are set forth in the margin.[15]

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[15] The parties have stipulated to the meaning of the following terms:

a. An “Aluminum-Lithium alloy” has the same meaning as “said alloy” in the claims of the ‘682 patent and means an aluminum alloy of the composition specified in each respective claim.

b. “Said alloy article” is a short-hand term for the article resulting from the process step “said alloy article first being formed into an article.”

The summary of the invention provided –

> The present invention provides a method for aging aluminum-lithium alloys of various compositions at relatively low temperatures to develop a high and improved fracture toughness without reducing the strength of the alloy. Simply, after the alloy is formed into an article, solution heat treated and quenched, the alloy is aged at a relatively low temperature for a relatively long time. This process may be generally referred to as low temperature underaging. More specifically, the alloy can be aged at temperatures ranging from 200° F. to below 300° F. for a period of time ranging from 1 up to 80 or more hours. This low temperature aging regimen will result in an alloy having a greater fracture toughness, often on the order of 150 to 200 percent, than that of materials aged at conventional higher temperatures while maintaining an equivalent strength.

"[T]he treatment will result in an aluminum-lithium alloy having an ultimate strength typically on the order of 45 to 95 ksi," the specification provided, "depending on the composition of the particular alloy," with "[t]he fracture toughness of the alloy . . . greater, often on the order of 1 ½ to 2 times greater, than that of similar aluminum-lithium alloys aged to equivalent strength levels by conventional aging treatments at temperatures greater than 300° F."

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c. "Amount (wt%)" means the quantity of a chemical element(s) in the alloy composition expressed as a percentage of the total weight of the composition.

d. "Solution heat treated" means that the alloy has been held at a suitably high temperature long enough to permit one or more constituents to enter into solid solution.

e. "Quenched" means to cool rapidly from an elevated temperature by contact with a liquid, a gas or a solid.

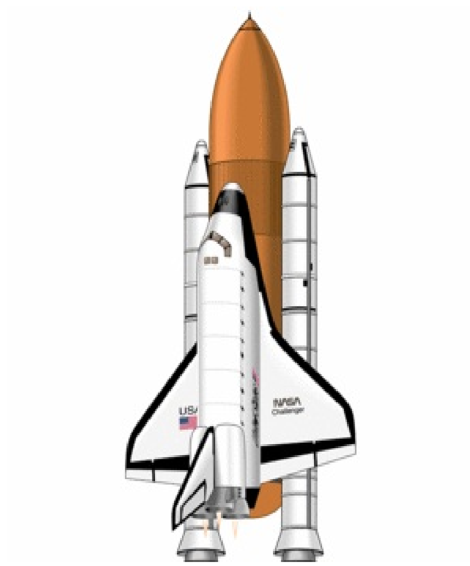
f. "Aging" means to change one or more of the properties of an alloy without changing its chemical composition, usually due to precipitation from a solid solution.

g. "Underaged" means that the alloy has not been aged sufficiently to obtain the maximum value for a certain property, such as hardness or strength, at a particular aging temperature.

Per this court's *Markman* opinion, a "trace element" means an undesired impurity, *Boeing*, 57 Fed. Cl. at 28, while "consisting essentially of" means that a group of listed ingredients is open to unlisted ingredients that do not materially affect the basic and novel properties of the invention, *id*. at 29.

D. The External Fuel Tank of the Space Shuttle

Boeing claims that panels on the Shuttle's external tank fabricated from Alloy 2195 infringe upon its '682 patent.



As the accompanying NASA diagram reveals, the Shuttle, officially called the Space Transportation System, consists of three main components: the reusable orbiter, two reusable solid rocket motors, and a large, brownish-orange, expendable external tank. The external tank not only carries the propellant for the Shuttle's main engines, but also serves as the structural backbone of the spaceship. While the Shuttle is on the launch pad during ignition and during its assent, a number of physical forces or "loads" act upon it, all of which are translated into and reacted by the external tank.

The first Shuttle mission was in 1981. The first external tanks are referred to, retrospectively, as Standard Weight Tanks (SWT). A weight reduction program in the early 1980s resulted in a redesigned external tank, the Lightweight Tank (LWT), which was approximately 5 tons lighter than the SWT. Then, as previously described, the need arose to shed further weight from the Shuttle, resulting, in 1995, in the Super Lightweight Tank (SLWT), which, as noted, is approximately 7,500 pounds lighter than the LWT. Each SLWT is 154 feet long and weighs 58,500 pounds empty. The first SLWT flew in a Shuttle mission in 1998.

The prime contractor to NASA for the production of the external tanks is Lockheed Martin Space Systems Company (its predecessor, Martin Marietta Corporation, had this role in the early days of the SLWT project). Lockheed Martin received the contract for the redesign of the external tank in 1994. Its suppliers include AHF-Ducommun (AHF) and AMRO Fabricating Corporation (AMRO). In some cases, these subcontractors contracted with others to perform processing associated with the external tank. For example, Tycorm, a subcontractor to AHF, sometimes aged panels of the SLWT.

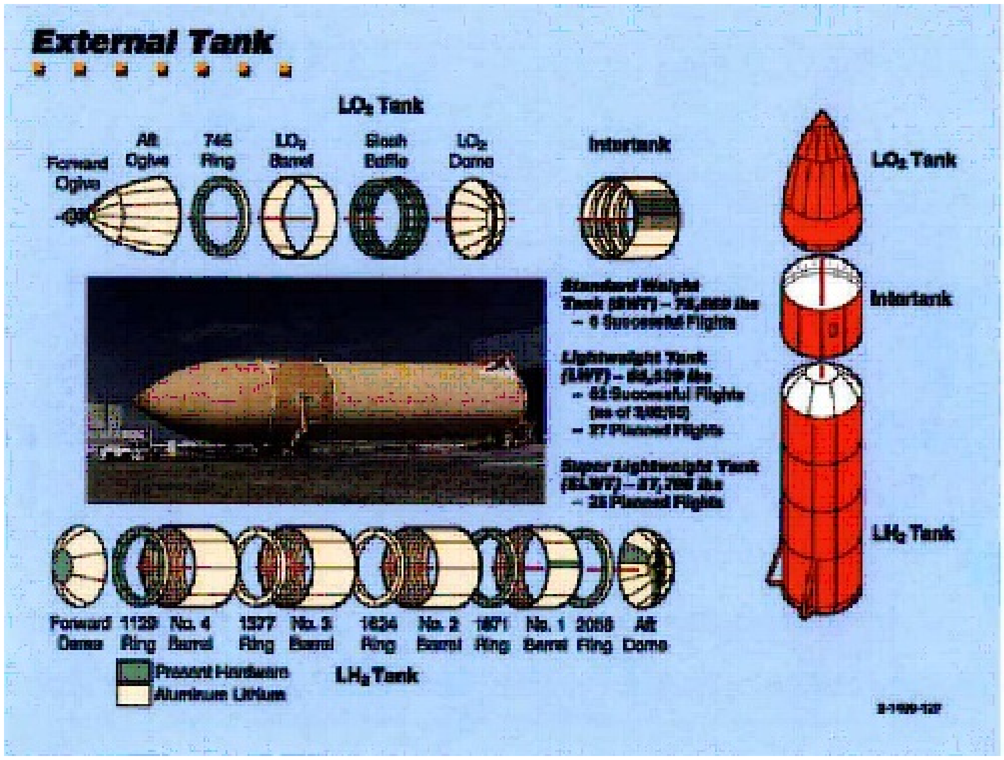
For reasons previously discussed, Lockheed Martin not only needed to reduce the density (weight reduction) of the alloys used on the external tank, but also needed to employ an alloy that had a good strength to fracture toughness ratio. The solution was Alloy 2195, which is both lighter and stronger than the alloy originally used in the fuel tank, Alloy 2219. Alloy 2195 is a member of the Weldalite family, and contains both silver and magnesium. It generally falls within the specific compositional range for the '682 patent, except for the addition of silver. Below is a side-by-side comparison of the composition of Alloy 2195 and the "acceptable composition" in the '682 patent:

Element	**2195 Amount (wt %)**	**'682 patent for "Acceptable" Amount (wt %)**
Li (lithium)	0.8 - 1.2	1.0 - 3.2
Mg (magnesium)	0.25 - 0.8	0 - 5.5
Ag (silver)	0.25 - 0.6	--
Cu (copper)	3.7 - 4.3	0 - 4.5
Zr (zirconium)	0.08 - 0.16	0.08 - 0.15
Mn (manganese)	0.25 max	0 - 1.2
Fe (iron)	0.15 max	0.3 max
Si (silicon)	0.12 max	0.5 max
Zn (zinc)	0.25 max	0.25 max
Ti (titanium)	0.10 max	0.15 max
Other trace elements:		
each	0.05 max	0.05 max
total	0.15 max	0.25 max
Al (aluminum)	Balance	Balance

As the trial exhibit below reveals, the major components of the SLWT are the Liquid Oxygen (LO_2 or LOX) tank, the intertank and the Liquid Hydrogen (LH_2) tank. The LO_2 tank and the LH_2 tank – the parts at issue herein – are welded pressure vessels, joined together by the intertank. These tanks originally were made of Alloy 2219. The LO_2 tank comprises, in part, a cylindrical section, an aft dome and two ogive sections. As can be seen from the accompanying exhibit, dome gores form the hemispherical portion of the aft end of the LO_2 tank, while barrel panels and ogive gores form the cylindrical portion and pointed forward end of that tank, respectively. At one point, all of these parts were made from Alloy 2195.[16] The intertank, a cross-beamed segment that connects the LO_2 and LH_2 tanks has never been made of Alloy 2195.

[16] Alloy 2195 is not the only aluminum-lithium alloy that has been used on the SLWT. Another such alloy, Alloy 2090, is used mainly as part of the support structure in the intertank and as part of the support structure in the baffle inside the LO_2 tank. Alloy 2090 does not contain silver.

The LH_2 tank comprises, in part, four cylindrical sections (formed by barrel panels), a forward dome and an aft dome (formed by gores), and attachment hardware for the orbiter. In creating the SLWT, the LH_2 tank was redesigned from a welded cylinder ring-framed, stiffened configuration to an orthogrid, or integrally machined, barrel panel.[17] At one point, almost all these parts were made from Alloy 2195. In terms of surface area, approximately 90 percent of the Alloy 2219 in the welded, pressure compartment applications of the external tank was changed to Alloy 2195.[18] The panels formed from Alloy 2195 are not all the same thickness.



In 1994, Lockheed experienced a problem with the fracture toughness ratio. This ratio was improved when a "tiger team" made up of NASA and Lockheed employees decided to drop the underaging treatment for Alloy 2195 from 320° F to 290° and 295° F. The LH_2 gores, LO_2 ogives, LO_2 gores, all aft and one forward ogive, caps, and the LO_2 barrels are aged at a temperature of [ ].

AMRO conducted the aging treatments for the LH_2 barrel panels, beginning, in 1995, by outsourcing the process to Astro; AMRO began aging the panels itself starting in 1996. The

[17] The LH_2 barrel panels could have been made with an orthogrid configuration with the Alloy 2219 material previously used in the tank. However, the higher strength of Alloy 2195 allows the orthogrid pattern to be machined deeper, thus resulting in a weight savings.

[18] Subsequently, due to manufacturing concerns, some of the ogives and domes were changed back to Alloy 2219, with other offsetting weight reductions.

aging cycle for a LH_2 barrel panel begins [ ]. This process iterates repeatedly about the set point.[19]

E. The Lawsuit

On November 21, 2000, plaintiff filed its complaint in this action. On May 13, 2003, a *Markman* hearing was held in this case, where the terms "consisting essentially of" and "other trace elements" were construed. An opinion construing these terms was issued June 20, 2003, *see Boeing*, *supra*. Following discovery, trial in this matter was conducted between November 15-19, 2004, with post-trial briefs, a further stipulation of facts, and closing arguments thereafter.

II. DISCUSSION

As noted, Boeing seeks compensation from the United States for NASA's unlawful use of the '682 patent in developing the SLWT for the Space Shuttle. Defendant's responses run the gamut. In cascading fashion, it claims that: (i) the relevant claims of the '682 patent are invalid due to anticipation and obviousness in light of the prior art, or limited by a terminal disclaimer; (ii) if those claims are valid, there is no infringement here because, *inter alia*, the content of Alloy 2195 and the process used to age the panels of the external fuel tank are different than that claimed in the '682 patent; and (iii) at all events, NASA had a license to employ the claimed invention. The court will consider defendant's assertions *seriatim*, but first must define a few additional terms in the patent.

A. Claim Construction

"It is a bedrock principle of patent law," the Federal Circuit has stated, "that the claims of a patent define the invention to which the patentee is entitled the right to exclude." *Innova/Pure Water, Inc. v. Safari Water Filtration Sys., Inc.*, 381 F.3d 1111, 1115 (Fed. Cir. 2004); *see also Aro Mfg. Co. v. Convertible Top Replacement Co.*, 365 U.S. 336, 339 (1961). Construing claims, including the terms of art found therein, is a matter of law. *Cybor Corp. v. FAS Techs., Inc.,* 138 F.3d 1448, 1456 (Fed. Cir. 1998) (en banc); *Markman v. Westview Instruments, Inc.*, 52 F.3d 967 (Fed. Cir. 1995) (en banc), *aff'd*, 517 U.S. 370 (1996). To ascertain the meaning of a claim term, the court refers to "those sources available to the public that show what a person of skill in the art would have understood disputed claim language to mean." *Phillips v. AWH Corp.*, 415 F.3d 1303, 1314 (Fed. Cir. 2005) (en banc) (*quoting Innova*, 381 F.3d at 1116). These sources include "the words of the claims themselves, the remainder of the specification, the prosecution history, and extrinsic evidence concerning relevant scientific principles, the meaning

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[19] Randy Mitchell of AMRO supervised the aging treatments of the LH_2 barrel panels. At his deposition, he testified that the working sensor of the aging oven "stay[ed] at 300 within a couple degrees." He did not, however, indicate as to any specific percentage of time that the temperature of the aging ovens for LH_2 barrel panels, as indicated by the working sensor, was above or below 300° F.

of technical terms, and the state of the art." *Id.* (*citing Innova*, 381 F.3d at 1116). It is important to "read the claim term not only in the context of the particular claim in which the disputed term appears, but in the context of the entire patent, including the specification." *Phillips*, 415 F.3d at 1313.

The Federal Circuit further has instructed that, "[w]hen construing a claim, a court should look first to the intrinsic evidence, *i.e.*, the claims themselves, the written description portion of the specification, and the prosecution history." *Bell & Howell Document Mgt. Prods. Co v. Altek Sys.*, 132 F.3d 701, 705 (Fed. Cir. 1997). "Such intrinsic evidence is the most significant source of the legally operative meaning of disputed claim language," the Federal Circuit has stated, because it "constitute[s] the public record of the patentee's claim, a record on which the public is entitled to rely." *Vitronics Corp. v. Conceptronic, Inc.*, 90 F.3d 1576, 1582-83 (Fed. Cir. 1996). Hence, the starting point for determining the meaning of a claim is the language of the claim itself. *Id.*; *see also Pitney Bowes, Inc. v. Hewlett-Packard Co.*, 182 F.3d 1298, 1305 (Fed. Cir. 1999). The words of a claim "are generally given their ordinary and customary meaning," *Vitronics Corp.*, 90 F.3d at 1582, that is, "the meaning that the term would have to a person of ordinary skill in the art in question at the time of the invention, *i.e.*, as of the effective filing date of the patent application." *Phillips*, 415 F.3d at 1313; *see also Innova*, 381 F.3d at 1116. Further, the specification "is always highly relevant to the claim construction analysis . . . . [I]t is the single best guide to the meaning of a disputed term." *Vitronics Corp.*, 90 F.3d at 1582.[20] Finally, "[t]he prosecution history is often helpful in understanding the intended meaning as well as the scope of technical terms, and to establish whether any aspect thereof was restricted for purposes of patentability." *Vivid Technologies, Inc. v. Am. Science & Eng'g, Inc.*, 200 F.3d 795, 804 (Fed. Cir. 1999). It "can often inform the meaning of the claim language by demonstrating how the inventor understood the invention and whether the inventor limited the invention in the course of prosecution, making the claim scope narrower than it would otherwise be." *Phillips*, 415 F.3d at 1317; *see also Lemelson v. Gen. Mills, Inc.*, 968 F.2d 1202, 1206 (Fed. Cir. 1992), *cert. denied*, 506 U.S. 1053 (1993).

But, what of extrinsic evidence, such as dictionaries, encyclopedias, treatises and expert testimony? In *Phillips*, the Federal Circuit rejected the emphasis given such evidence in *Texas Digital Sys., Inc. v. Telegenix, Inc.*, 308 F.3d 1193 (Fed. Cir. 2002), *cert. denied*, 538 U.S. 1058 (2003), cautioning that giving undue weight to extrinsic evidence "improperly restricts the role of the specification in claim construction." *Phillips*, 415 F.3d at 1320. While the court, in *Phillips*, thus clarified that intrinsic evidence should be accorded greater weight than extrinsic evidence, it did not discount the latter category of evidence altogether, finding that it "can shed useful light on the relevant art." *Id.* at 1317 *(quoting C.R. Bard, Inc. v. U.S. Surgical Corp.*, 388 F.3d 858, 862 (Fed. Cir. 2004)). Accordingly, extrinsic evidence "may be considered if the court deems it helpful in determining the true meaning of language used in the patent claims," *id.* at 1318 (internal quotations omitted), provided the court "attach[es] the appropriate weight . . . to those sources in light of the statutes and policies that inform patent law." *Id.* at 1324; *see also Terlep v. Brinkmann*

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[20] *See also Renishaw PLC v. Marposs Societa' per Azioni*, 158 F.3d 1243, 1250 (Fed. Cir. 1998) ("The construction that stays true to the claim language and most naturally aligns with the patent's description of the invention will be, in the end, the correct construction.").

Corp., 418 F.3d 1379, 1382 (Fed. Cir. 2005). In particular, judges must consider dictionaries while keeping in mind that "the specification is the 'single best guide to the meaning of a disputed term,' and that the specification 'acts as a dictionary when it expressly defines terms used in the claims or when it defines terms by implication.'" *Phillips*, 415 F.3d at 1321 *(quoting Vitronics Corp*., 90 F.3d at 1582); *see also Irdeto Access, Inc. v. Echostar Satellite Corp*., 383 F.3d 1295, 1300 (Fed. Cir. 2004).

As noted, this court has previously construed various elements of the claims at issue. *Boeing*, 57 Fed. Cl. at 28-29. Although those constructions predated *Phillips*, this court fortunately concluded that "[t]he meaning of the elements in question is derivable from the intrinsic record, standing alone . . . consistent with the specification and in the context of the prosecution history." *Boeing*, 57 Fed. Cl. at 28. The constructions thus remain valid in the wake of the Federal Circuit's more recent teachings on the subject. Nevertheless, two additional elements of the '682 patent must yet be construed, as reflected in the highlighted terms of claim 1 which reads – "said process comprising the step of aging said alloy article to a ***predetermined underaged strength level*** at from about 200° F. to ***less than 300° F***."

1. "predetermined underaged strength level"

The initial focus here is on the word "predetermined." Plaintiff contends that the "predetermined" underaged strength is determined before or independently from the other portions of the process – and then the aging time and temperature are tailored to achieve that strength level. Not so, defendant submits. Rather, it asserts, the "'underaged strength level' is predetermined by the selection of the aging time and temperature," with the resulting strength level thereby being "predetermined" even though the result is not known until after the process is completed. Plaintiff retorts that if this were the proper construction, the word "predetermined" would have no meaning – and thus serve no purpose – in claim 1 of the '682 patent.

The word "predetermined" is a simple term that yields up its meaning quite readily. The Federal Circuit has indicated, in several patent cases, that "[t]he ordinary meaning of 'predetermine' is 'to determine beforehand.'" *Ferguson Beauregard/Logic Controls v. Mega Sys. LLC*, 350 F. 3d 1327, 1340 (Fed. Cir. 2003) (citing Webster's Third New International Dictionary 1786 (1966)).[21] This ordinary meaning is not altered by the '682 patent, the specification of which provides that the process enumerated is designed to maintain (or not reduce) the strength of a given aluminum-lithium alloy while improving its fracture toughness. In other words, the process allows one to age an alloy to a "predetermined" strength level, with the result, according to the specification, that

[21] *See also, e.g., Pause Technology, LLC v. TiVo, Inc*., 419 F.3d 1326, 1333 (Fed. Cir. 2005) ("predetermined duration" was "determined before the time interval began"); *Koito Mfg. Co. v. Turn-Key-Tech, LLC*, 381 F.3d 1142, 1148 (Fed. Cir. 2004) ("predetermined general direction" means the "prevalent direction of the plastic flow be determined before the injection of the liquid plastic into the mold"); *Abbott Labs. v. Syntron Bioresearch, Inc.*, 334 F.3d 1343, 1353 (Fed. Cir. 2003) (district court properly defined "predetermined amount" as "an amount determined beforehand"); *and see Mediacom Corp v. Rates Tech.*, 4 F. Supp. 2d 17, 30-31 (D. Mass. 1998) ("predetermined" signifies that parameters "must be selected substantially in advance").

"[t]he fracture toughness of the alloy will be greater, often on the order of 1½ to 2 times greater than that of similar aluminum-lithium alloys aged to equivalent strength levels." That the desired strength of the alloy is to be determined in advance is apparent from the fact that, according to the claim language, the process relates to the aging of already-formed articles, rather than raw metal – the description refers to these as "usable article[s]" created "by conventional mechanical forming techniques such as rolling, extrusion, or the like," and gives as an example aircraft structural parts. Logic suggests that one would not fabricate a part out of a given aluminum-lithium alloy without knowing whether the strength the aging process would yield would work for the purpose intended. As Dr. Hunt testified, "[p]redetermined strength level comes and is typically driven by the requirements of the design," that is, the process of the patent is designed to obtain an article whose strength is known beforehand, and to do so, while improving fracture toughness.

By contrast, defendant's expert, Dr. Starke, could not specifically define what he meant by "a predetermined underaged strength level," stating, somewhat diffidently, only that such a level was predetermined by the time and temperature selected on aging curves that would need to be developed for a particular alloy and suggesting, under that scenario, that strength thus could be "predetermined" even if it was not known beforehand. In so asserting, however, Dr. Starke seemingly ignored the fact that the patent purports to provide precisely those aging curves for alloys within its composition range. Pressed, he admitted that under his definition, the word "predetermined" was superfluous and thus played no role in giving content to the patent.[22] This view conflicts not only with the surrounding claim language, but also with the basic notion that "[a] claim construction that gives meaning to all the terms of the claim is preferred over one that does not do so." *Merck & Co. v. Teva Pharm. USA, Inc.*, 395 F.3d 1364, 1372 (Fed. Cir.), *cert. denied*,

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[22] At trial, the following telling exchange occurred between Dr. Starke and the court:

Q: [U]nder your definition of the term predetermined . . . take a look at that sentence [of the patent] now, again, wouldn't the sentence have the same meaning if you deleted the word predetermined? Does it serve any purpose in that sentence?

A: No.

Q: No, it serves no purpose.

A: I don't believe.

Q: . . . So the step of aging [said] alloy, article [to a] underaged strength level, it would have the same meaning as far as you're concerned?

A: As far as I'm concerned, yes.

126 S.Ct. 488 (2005).[23] Indeed, in *Pause Technology,* 419 F.3d at 1334, the Federal Circuit made short shrift of a construction of the patent that would have "attache[d] no significance to the word 'predetermine,'" as used in a patent for a digital recorder, noting that "[i]n construing claims, . . . we must give each claim term the respect that it is due." Consistent with these precedents, this court will not adopt a construction of "predetermined" that essentially would render that term moribund.

Contrary to defendant's claims, the key to the invention is that one can preselect the strength and the fracture toughness, and then determine what aging parameters, *i.e.,* aging time and temperature, are needed to produce those features. It is in this context, and primarily by reference to the patent itself, that the court defines the phrase "predetermined underaged strength level" as one determined before the aging process described in the patent is applied.

2. "less than 300° F"

Although the parties have not, in so many words, requested a construction of the phrase "less than 300° F," as used in claim 1 of the patent, they clearly are at loggerheads as to its meaning. Because, as will be seen, the true meaning of this phrase is pivotal in resolving several of the infringement issues herein, the court, considering the parties' differing definitions, believes that it is necessary, by way of further prelude, to construe this phrase.[24]

Defendant essentially contends that one knowledgeable in the field would know that the reference to "less than 300° F" is to the set point of a commercial oven and that the phrase should be strictly construed to the decimal point (and beyond). Under this definition, this claim would not be met if, for example, such an oven was set at 300° F, even if research revealed that all or portions of the oven never actually reached that temperature. For its part, plaintiff claims that this reference is not to the set point of a commercial oven, but rather to the actual temperature employed in aging an article. Under this latter definition, to the extent data showed that a significant portion of the aging of a particular article was done at a temperature less than 300° F, the requirements of the claim would be met – and this would be true even if the commercial aging oven used was set at 300° F or even higher.

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[23] *See also Elekta Instrument S.A. v. O.U.R. Sci. Int'l, Inc.*, 214 F.3d 1302, 1307 (Fed. Cir. 2000) (construing claim to avoid rendering the 30 degree claim limitation superfluous); *Gen. Am. Transp. Corp. v. Cryo-Trans, Inc.*, 93 F.3d 766, 770 (Fed. Cir. 1996), *cert. denied*, 520 U.S. 1155 (1997) (rejecting the district court's claim construction because it rendered superfluous the claim requirement for openings adjacent to the end walls).

[24] Notably, the Federal Circuit has indicated that trial courts have considerable discretion in determining when to resolve issues of claim construction and may even revisit prior constructions, as circumstances warrant. *See, e.g., CytoLogix Corp. v. Ventana Med. Sys., Inc.*, 424 F.3d 1168, 1172 (Fed. Cir. 2005); *Jack Guttman, Inc. v. Kopykake Enters., Inc.*, 302 F.3d 1352, 1361 (Fed. Cir. 2002).

Again, we begin with the intrinsic evidence. The patent and its prosecution history repeatedly refer, in sundry ways, to underaging aluminum-lithium alloys at certain "temperatures," but never mention ovens of any sort, let alone commercial ones versus those used in laboratories, leaving the distinct impression that those references allude not to oven settings, but to the actual temperature being encountered by the alloy during the process. Indeed, the specification refers to other steps of the underaging process in which aluminum-lithium alloys are homogenized, solution-treated and quenched at specified temperatures, even though the record suggests those treatments do not always occur in ovens. Presumably, if the underaging temperature reference in claim 1 meant an oven setting, the language employed there would have listed that feature, if only to distinguish that reference from the other temperatures described elsewhere in the patent. *See Fin Control Sys. Pty., Ltd. v. OAM, Inc.*, 265 F.3d 1311, 1318 (Fed. Cir. 2001) ("The same terms appearing in different portions of the claims should be given the same meaning unless it is clear from the specification and prosecution history that the terms have different meanings at different portions of the claims."). Of course, it did not. Moreover, a review of the prosecution history reveals numerous references to various temperatures, ordinarily expressed in degrees Fahrenheit, but not a scintilla of evidence that when the inventors referred to an underaging temperature, they meant the set point of an oven, rather than the actual temperature at which the alloy was aging.

Not all the intrinsic evidence, however, slants plaintiff's way. The language in claim 1 describes the step of aging said alloy article "at" from 200° F to less than 300° F. Notably, in other cases involving processes that rely upon temperatures, the Federal Circuit has distinguished between claim language indicating that an article is to be processed "at" a given temperature versus language stating that such an article is to be processed "to" a set temperature. In these cases, "at" has been construed to refer to the ambient temperature, that is, the temperature of the air of an oven or similar heating instrumentality, while the word "to" has been construed to require that the article being processed itself attain the specified temperature.[25] In none of these cases, however, was the court required to determine whether a temperature reference was to the setting of a heating instrumentality, rather than the actual temperature obtained from that unit. Nor did any of these cases construe the language based solely upon the plain meaning thereof; instead, they relied not only on other intrinsic evidence (*e.g.*, the specification and the prosecution history), but also extrinsic evidence. *See, e.g, Eastman Kodak Co.*, 114 F.3d at 1554-56. But, here, neither the specification nor the patent history suggests that the temperature referenced in claim 1 is to the set point of a commercial oven. Accordingly, the court must consult extrinsic evidence to get a better hold on how one knowledgeable in the art would view such a temperature reference.

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[25] *See Chef America, Inc. v. Lamb-Weston, Inc.*, 358 F.3d 1371, 1373-74 (Fed. Cir. 2004) (requirement that batter-coated dough be heated "to" particular temperature range meant that the dough itself, and not merely the air in the oven where the dough was placed, had to be heated to the designated range); *Eastman Kodak Co. v. Goodyear Tire & Rubber Co.*, 114 F.3d 1547, 1553 (Fed. Cir. 1997), *abrogated, on other grounds*, *by Cybor Corp. v. FAS Technologies, Inc*., 138 F.3d 1448 (Fed. Cir. 1998) (claim calling for granulate to be crystallized "at" a temperature range referred to "a process condition, not the condition of the matter under process"); *see also Invitrogen Corp. v. Biocrest Mfg*., L.P., 327 F.3d 1364, 1367-70 (Fed. Cir. 2003) (construing a process that required growth of cells "at" a specified temperature range).

To be sure, defendant's expert witness, Dr. Starke, testified that the underaging temperature range in claim 1 referred to the set point of commercial ovens. But, on cross-examination, he freely admitted that he was not familiar with such ovens and that the inventors would have no idea which of the wide variety of ovens commercially employed (*e.g.*, quartz radiant tube, high frequency induction, molten metal bath, electric resistance, molten salt bath) would actually be used in performing their process. The latter point is notable because the record reveals that there are significant variations among commercial ovens in terms of how efficiently and evenly they maintain a given temperature – so many variations, indeed, that the underaging of aluminum-lithium alloys is commonly conducted not by relying on the oven temperature, even if periodically calibrated, but by attaching thermocouples to the article being underaged to ensure that various segments and zones thereof are, over the hours required, actually aged at an appropriate temperature. Various treatises on aluminum and heat treating that were introduced into evidence emphasize the importance of having the metal load reach the bottom limit of the heat-treating range (usually expressed in terms of a plus or minus range around a given temperature), but not exceed the upper limit of that range (a defect referred to as "burning"). These same treatises emphasize that individual treatments are influenced by the size of the load, as well as the type of furnace and other foundry variables, and that the treatment time may have to be adjusted by experiment or experience to secure the appropriate aging temperature.[26] This information, much of which was confirmed by Dr. Hunt in his testimony and expert report, indicates that one skilled in the art would read the temperature references in claim 1 of the '682 patent as referring to the actual temperature at which underaging of an article is occurring, not an oven set point.

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[26] *See* "Heat-Treatment of Aluminum Alloys," Handbook of Aluminum 208 tbl.6 n.1 (Aluminum Co. Of Canada, Ltd., 1957) ("The time at temperature varies with the product, the type of furnace and the size of load."); *see also id.* at 214 tbl.11 n.2; "Heat Treating of Aluminum Alloys," 4 Metals Handbook 666-83 tbl.1 n.(b) (Am. Society for Metals, 9th ed. 1981). These treatises indicate that heat treatment temperatures are ordinarily viewed as a range, *e.g.,* the desired temperature plus or minus 3 to 5 degrees, and that adjustments must be made in performing commercial aging treatments to ensure that the alloy is maintained within the nominal temperature range for the required period of time. *See, e.g.*, 4 Metals Handbook, *supra*, at 700 (noting the need to consider "allowances for variables such as composition within specified range and temperature variations within the furnace and load."). They suggest the use of thermocouples or pyrometers to ensure that the article being treated is actually being aged at an appropriate temperature, counseling that "[h]eat-treatment 'time at temperature' is calculated from the moment the coldest part of the load has reached the lower limit of the heat-treating range." Handbook of Aluminum, *supra*, at 78. "For thick sections a schedule of recoveries should be determined by experiment using 'load couples', pyrometers inserted in the centre of sample aluminum slabs of equal size to the thickest section." *Id.* Confirming these practices, the record in this case shows that similar approaches – focusing on the actual temperatures reached by the article being aged – were employed by NASA's contractors here in underaging the various parts of the external tank.

Based on the foregoing, this court concludes that the phrase "less than 300° F" refers to the actual temperature at which underaging is occurring and not necessarily to the set point of the oven that effectuates that underaging.

B. Validity of the '682 Patent

In terms of validity, we begin with common ground: patent claims are presumed valid, 35 U.S.C. § 282 (2004), and the burden of establishing to the contrary rests on the party asserting invalidity, which must prove the facts supporting invalidity by clear and convincing evidence. *See Georgia-Pacific Corp. v. U.S. Gypsum Co.*, 195 F.3d 1322, 1329 (Fed. Cir. 1999), *cert. denied*, 531 U.S. 816 (2000); *Massey v. Del Labs., Inc.*, 118 F.3d 1568, 1573 (Fed. Cir. 1997). The court will consider defendant's various challenges to the validity of the '682 patent in succession.

1. Anticipation

Defendant first asserts that claims 1 and 7 of the patent are invalid on grounds of anticipation under 35 U.S.C. § 102(a), which provides that "[a] person shall be entitled to a patent unless – (a) the invention was known or used by others in this country, or patented or described in a printed publication in this or a foreign country, before the invention thereof by the applicant for patent." Based on this subsection, it is well settled that a claim is anticipated, and thus invalid, if each and every limitation is found either expressly or inherently in a single prior art reference. *See Brown v. 3M*, 265 F.3d 1349, 1351 (Fed. Cir. 2001), *cert. denied*, 535 U.S. 970 (2002); *Celeritas Tech., Ltd. v. Rockwell Int'l Corp.*, 150 F.3d 1354, 1361 (Fed. Cir. 1998), *cert. denied*, 525 U.S. 1106 (1999); *Structural Rubber Prods. Co. v. Park Rubber Co.*, 749 F.2d 707, 715 (Fed. Cir. 1984). "To establish inherency," the Federal Circuit stated, "the extrinsic evidence 'must make clear that the missing descriptive matter is necessarily present in the thing described in the reference, and that it would be so recognized by persons of ordinary skill.'" *In re Robertson*, 169 F.3d 743, 745 (Fed. Cir. 1999) (*quoting Continental Can Co. USA v. Monsanto Co.*, 948 F.2d 1264, 1268 (Fed. Cir. 1991)). Such inherency may not be established by "'probabilities or possibilities.'" *Continental Can*, 948 F.2d at 1269 (quoting *In re Oelrich*, 666 F.2d 578, 581 (C.C.P.A. 1981) (internal citations omitted)). Summing up these standards, the Federal Circuit has instructed that "if granting patent protection on the disputed claim would allow the patentee to exclude the public from practicing the prior art, then that claim is anticipated, regardless of whether it also covers subject matter not in the prior art." *Atlas Powder Co. v. Ireco, Inc.*, 190 F.3d 1342, 1346 (Fed. Cir. 1999).

Relying on claims charts employed by Dr. Starke, defendant charges that each of the elements of claims 1 and 7 of the patent are found literally in one or more of the following sources: (i) Criner Patent No. 2,915,391 (Criner); (ii) a paper by I.N. Fridlyander, *et al.*, entitled "High-Strength Heat-Resistant and Structural Alloys of Aluminum with Lithium" (1972) (Fridlyander)[27];

[27] This reference was from Chapter 7 of a 1972 book in Russian, entitled *Alyuminyevyye Splavy* (Aluminum Alloys), which was translated into English in 1974. This chapter contains

(iii) a paper by Yu. M. Vaynblat, *et al.*, entitled "Subboundary Embrittlement of the Alloy Al-Mg-Li by Horophile Impurity Sodium" (1976) (Vaynblat); or (iv) a paper by V. Fedoseev entitled "Examination of the Mechanical Properties of Welded Joints in the 01420 Alloy" (1981) (Fedoseev). But, a fatal flaw underlies this analysis, as Dr. Starke clearly arrived at his views using his own idiosyncratic definition of the phrase "predetermined underaged strength," which has now been debunked. Indeed, on cross-examination, Dr. Starke admitted that under plaintiff's definition of that phrase – the one this court has adopted – none of the identified prior art sources anticipated the patent. Accordingly, impeached by his own testimony – the only real testimony offered by defendant on this point – Dr. Starke essentially admitted that the cited references do not anticipate claims 1 and 7 of the '682 patent. *See Chem. Separation Tech. Inc. v. United States*, 51 Fed. Cl. 771, 813-14 (2002) (expert testimony that relied on rejected claim constructions inadequate to demonstrate anticipation). This court perceives no basis to disagree with him.

Particularly this is so, as careful review of the references cited by Dr. Starke betrays clear and important differences between claims 1 and 7 of the '682 patent and what is taught in Criner, Fridlyander, Vaynblat and Fedoseev. For example, Criner, which was considered by the U.S. Patent Office during the prosecution of the '682 patent, treats cadmium as an essential alloying element, while under the patent, cadmium is an undesirable "trace element," defined by this court not as an alloying element, but an impurity.[28] Criner, moreover, focuses on using a range of temperatures to improve strength, but not on using the types of temperatures listed in the '682 patent to improve fracture toughness with no loss in strength – indeed, Criner makes no reference to fracture toughness at all. Similar dissimilitudes readily distinguish the '682 patent from Fridlyander, which also was considered by the Patent Office in issuing the '682 patent. Vaynblat is even more far afield, as it focuses only on the combination of strength and fracture toughness measured at a single aging temperature of 248° F. Finally, Fedoseev did not study a range of temperatures and discloses no way to improve fracture toughness without detracting from the strength of the aluminum-lithium alloys. Dr. Starke candidly admitted to most of these points on cross-examination, further buttressing the court's findings. Thus, defendant's proof on this issue falls far short of the clear and convincing evidence required to invalidate the patent on the grounds of anticipation.

2. Obviousness

Continuing this *tour d'horizon*, the court next considers whether claims 1 and 7 of the '682 patent are invalid on grounds of obviousness under 35 U.S.C. § 103(a).

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two articles by Fridlyander, the second of which, "Structural Alloy 01420," is the one which defendant actually relies upon.

[28] In this regard, the specification of the '682 patent states that "[c]ertain other trace elements such as cadmium and chromium must each be held to levels of 0.05 percent or less. If these maximums are exceeded, the desired properties of the aluminum-lithium alloy will tend to deteriorate."

A patent is invalid for obviousness when differences between its claims and prior art "are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art." 35 U.S.C. § 103(a). "While the ultimate determination whether an invention would have been obvious is a question of law," this court has stated, "this conclusion is based on the totality of the evidence and informed *vel non* by four underlying factual inquiries: (1) the scope and content of the prior art; (2) the level of ordinary skill in the prior art; (3) the differences between the claimed invention and the prior art; and (4) any objective evidence of nonobviousness, such as long felt need, commercial success, the failure of others, or copying." *Chem. Separation*, 51 Fed. Cl. at 793.[29] The so-called *Graham* factors – derived from Justice Clark's opinion in *Graham v. John Deere Co. of Kan. City*, 383 U.S. 1, 17-18 (1966) – guide in determining "whether the prior art would have suggested to one of ordinary skill in the art that this process should be carried out and would have a reasonable likelihood of success, viewed in the light of the prior art." *Brown and Williamson Tobacco Corp.*, 229 F.3d at 1124 (quoting *In re Dow Chem.*, 837 F.2d 469, 473 (Fed. Cir. 1988)). Defendant must prove any factual predicates underlying the factors by clear and convincing evidence. *See Glaxo Group Ltd. v. Apotex, Inc.*, 376 F.3d 1339, 1348 (Fed. Cir. 2004); *Estate of Wicker*, 43 Fed. Cl 172, 181 (1999), *aff'd*, 232 F.3d 907 (Fed. Cir. 2000). This burden is "'especially difficult' when . . . the infringer attempts to rely on prior art that was before the patent examiner during prosecution." *Glaxo Group*, 376 F.3d at 1348 (quoting *Al-Site Corp. v. VSI Int'l Inc.*, 174 F.3d 1308, 1323 (Fed. Cir. 1999)).

Defendant asserts that the critical elements in the claims of the '682 patent were all shown in the prior art and that it would have been obvious to one skilled in the art in December 1982 to alter or combine that art to produce the '682 patent. The court will analyze these assertions, and plaintiffs' responses thereto, in the context of the four *Graham* factors identified above. *See Ruiz v. A.B. Chance Co.*, 234 F.3d 654, 663-64 (Fed. Cir. 2000) (noting the need for the court to make specific findings with respect to the four *Graham* factors in determining obviousness).

a. The scope and content of the prior art

The scope of the relevant prior art includes "not only the field of the inventor's endeavor," but also that "'reasonably pertinent to the particular problem with which the inventor was involved.'" *In re GPAC Inc.*, 57 F.3d 1573, 1577-78 (Fed. Cir. 1995) (quoting *Stratoflex, Inc. v. Aeroquip Corp.*, 713 F.2d 1530, 1535 (Fed. Cir. 1983) (internal citation omitted)); *see also Princeton Biochem., Inc. v. Beckman Coulter, Inc.*, 411 F.3d 1332, 1338 (Fed. Cir. 2005). "References that are not within the field of the inventor's endeavor may also be relied on in patentability determinations, and thus are described as 'analogous art,' when a person of ordinary skill would reasonably have consulted those references and applied their teachings in seeking a

[29] *See also Merck*, 395 F.3d at 1372-73; *Brown & Williamson Tobacco Corp. v. Phillip Morris, Inc.*, 229 F.3d 1120, 1124 (Fed. Cir. 2000); *B.F. Goodrich Co. v. Aircraft Braking Sys. Corp.*, 72 F.3d 1577, 1582 (Fed. Cir. 1996).

solution to the problem that the inventor was attempting to solve." *In re GPAC,* 57 F.3d at 1578 (quoting *Heidelberger Druckmaschinen AG v. Hantscho Commercial Prods., Inc.*, 21 F.3d 1068, 1071 (Fed. Cir. 1994) (citation omitted)); *see also* Robert L. Harmon, Patents and the Federal Circuit § 4.4 at 184-86 (7th ed. 2005). With respect to prior art, "[w]hile a reference must enable someone to practice the invention in order to anticipate under § 102(b), a non-enabling reference may qualify as prior art for the purpose of determining obviousness under § 103." *Symbol Tech., Inc. v. Opticon, Inc.*, 935 F.2d 1569, 1578 (Fed. Cir. 1991).

In the case *sub judice*, defendant challenges claims 1 and 7 of the '682 patent, advancing that every element thereof is found in the prior art references of Fridlyander in combination with a 1960 article by W. Jones and P. Das, entitled "The Mechanical Properties of Aluminum-Lithium Alloys" (Jones and Das). Plaintiff does not contest that these references are analogous prior art. Based upon the record, the court concludes that the referenced prior art would have been consulted by a person of ordinary skill attempting to solve the problem surmounted by the '682 patent.

b. The level of ordinary skill in the prior art

The person of ordinary skill in the art is a legal construct – a hypothetical person who is placed in the position of being aware of all of the relevant prior art. *Custom Accessories, Inc. v. Jeffrey-Allan Indus., Inc.*, 807 F.2d 955, 962 (Fed. Cir. 1986); *see also In re GPAC*, 57 F.3d at 1579. In determining this individual's level of skill, a court may consider several factors, including the kinds of problems existing in the art, the solutions to the problems in the prior art, the rate at which new innovations are made in the field, the complexity of the technology, and the educational level of active workers in the field. *Custom Accessories*, 807 F.2d at 962; *see also Ruiz,* 234 F.3d at 666-67; *Gargoyles, Inc. v. United States*, 32 Fed. Cl. 157, 165 (1994), *aff'd*, 113 F.3d 1572 (Fed. Cir. 1997). Not all such factors may be present in every case, and one or more of them may predominate. *Custom Accessories,* 807 F.2d at 962-63; *see also In re GPAC*, 57 F.3d at 1579. Notably absent from this list is the level of skill of the inventors of the patents, which is generally not determinative. *See Helifix Ltd. v. Blok-Lok, Ltd.*, 208 F.3d 1339, 1347-48 (Fed. Cir. 2000); *Custom Accessories* 807 F.2d at 962; *Standard Oil Co. v. Am. Cyanamid Co.*, 774 F.2d 448, 454 (Fed. Cir. 1985) (the "actual inventor's skill is irrelevant to the inquiry").

Dr. Starke testified that, in his opinion, one of ordinary skill in the art "would have a degree in metallurgical engineering, with some courses possibly in aluminum alloy metallurgy and possibly having a degree in mechanical engineering or aerospace engineering, also with courses in metallurgy." While plaintiff speculated that one of ordinary skill might be as relatively unsophisticated as a technician who quenches aluminum-lithium alloys, it did not produce evidence to that effect – indeed, in his expert report, Dr. Hunt essentially agreed with Dr. Starke, stating that "[o]ne of ordinary skill in the art of [aluminum-lithium] alloys would have at least a four year degree in metallurgy or the equivalent, and significant, *e.g.*, years of experience working with [such] alloys and, in particular, the low temperature underaging of such alloys." Consequently, the court finds that Dr. Starke's definition should be applied here.

c. The differences between the claimed invention and the prior art

"Although the four *Graham* factors indisputably form the skeletal framework of the obviousness analysis, the backbone of that analysis . . . is the comparison of the claimed invention with the prior art." *Chem. Separation*, 51 Fed. Cl. at 795; *see also Graham*, 383 U.S. at 17. Regarding this third, often decisive, *Graham* factor, the Federal Circuit has stated that "[i]n determining whether obviousness is established by combining the teachings of the prior art, 'the test is what the combined teachings of the references would have suggested to those of ordinary skill in the art.'" *In re GPAC*, 57 F.3d at 1581 (quoting *Cable Elec. Prods., Inc. v. Genmark, Inc.*, 770 F.2d 1015, 1025 (Fed. Cir. 1985) (internal citation omitted)); *see also C.R. Bard, Inc. v. M3 Systems, Inc.*, 157 F.3d 1340, 1351 (Fed. Cir. 1998), *cert denied*, 526 U.S. 1130 (1999); *Heidelberger Druckmaschinen AG*, 21 F.3d at 1072; *N. Telecom, Inc. v. Datapoint Corp.*, 908 F.2d 931, 934 (Fed. Cir.), *cert. denied*, 498 U.S. 920 (1990). In order to find obviousness, then, the combined teachings of the prior art must suggest the improvements embodied by the invention. *In re Sernaker*, 702 F.2d 989, 994 (Fed. Cir. 1983).

Defendant relies on Jones and Das to demonstrate low temperature aging at less than 300° F, but recognizes that this reference does not teach the use of an aluminum-lithium alloy with zirconium in the range covered by the '682 patent. By way of combination, defendant relies on Fridlyander for the latter concept. However, as Dr. Starke admitted, the critical gap here again is that neither Fridlyander nor Jones and Das, individually or in combination, discusses aging to what this court has defined as a "predetermined underaged strength level." As Dr. Hunt emphasized, this is not surprising as these references neither show nor suggest the measurement of fracture toughness, nor, in particular, an increase in fracture toughness with no loss in strength. In fact, Jones and Das was published in 1960, before the concept of fracture toughness was developed, while Fridlyander suggests that various properties of aluminum-lithium alloys may be improved with low temperature aging, but only accepting a loss in strength. Accordingly, there appear to be major differences between these prior art references and the '682 patent.

Even accepting that either Fridlyander or Jones and Das somehow teaches aging to a "predetermined underaged strength level," defendant's proof on this issue falls short of showing the sort of suggestion, teaching or incentive to combine features that the Federal Circuit has required to demonstrate obviousness.[30] "This showing must be clear and particular," the Federal Circuit has stated, and beyond "broad conclusory statements about the teaching of multiple references." *Brown & Williamson Tobacco*, 229 F.3d at 1125; *see also In re Dembiczak*, 175 F.3d 994, 1000 (Fed. Cir. 1999). Of the two contrasting evidentiary standards in this quote – one

[30] *See In re Sang Su Lee*, 277 F.3d 1338, 1343 (Fed. Cir. 2002) (citing numerous cases); *Brown & Williamson Tobacco Corp.*, 229 F.3d at 1124-25 ("a showing of a suggestion, teaching, or motivation to combine the prior art references is an 'essential evidentiary component of an obviousness holding'") (quoting *C.R. Bard, Inc.*, 157 F.3d at 1352); *In re Rouffet*, 149 F.3d 1350, 1359 (Fed. Cir. 1998); *Chem. Separation*, 51 Fed. Cl. at 797 (summarizing related principles).

describing what is required, the other what is lacking – defendant's views on combination resemble the latter. Its arguments are far too conclusory to carry the day, suggesting little more than that because the '682 patent combined these elements, others skilled in the art would have done the same. But, this is precisely the *ipse dixit* so often rejected by the Federal Circuit. On one such occasion, the court cautioned that "[t]o imbue one of ordinary skill in the art with knowledge of the invention in suit, when no prior art reference or references of record convey or suggest that knowledge, is to fall victim to the insidious effect of a hindsight syndrome wherein that which only the inventor taught is used against its teacher." *W.L. Gore & Assoc., Inc. v. Garlock, Inc.*, 721 F.2d 1540, 1553 (Fed. Cir. 1983), *cert. denied*, 469 U.S. 851 (1984). Only by insisting upon this rigor can the court avoid entry into the "tempting but forbidden zone of hindsight," *Loctite Corp. v. Ultraseal Ltd.*, 781 F.2d 861, 873 (Fed. Cir. 1985), *overruled on other grounds by Nobelpharma AB v. Implant Innovations, Inc.*, 141 F.3d 1059 (Fed. Cir.), *cert. denied*, 525 U.S. 876 (1998); *see also Ruiz.*, 234 F.3d at 663. And here that rigor is conspicuously lacking.

d. Any objective evidence of nonobviousness

In an obviousness analysis, objective evidence of nonobviousness must be considered if present. *In re GPAC*, 57 F.3d at 1580. This evidence includes, *inter alia*, "the commercial success of the patented invention, whether the invention meets 'long felt but unsolved needs' and the failure of others to produce alternatives to the patented invention." *Id.* (quoting *Graham*, 383 U.S. at 17-18). Objective evidence is accorded substantial weight only where the proponent establishes a nexus between such evidence and the merits of the claimed invention. *Id.*; *see Simmons Fastener Corp. v. Illinois Tool Works, Inc.*, 739 F.2d 1573, 1574-76 (Fed. Cir. 1984), *cert. denied*, 471 U.S. 1065 (1985); *Stratoflex*, 713 F.2d at 1539; *B.E. Meyers & Co. v. United States*, 47 Fed. Cl. 375, 378 (Fed. Cl. 2000). "A prima facie case of nexus is generally made out when the patentee shows both that there is commercial success, and that the thing (product or method) that is commercially successful is the invention disclosed and claimed in the patent." *Demaco Corp. v. F. Von Langsdorff Licensing Ltd.*, 851 F.2d 1387, 1392 (Fed. Cir.), *cert. denied*, 488 U.S. 956 (1988).

In the case *sub judice*, the evidence on this factor is scant and derives primarily from proof of other points. Various testimony, however, established that the patent met a long-desired result, namely, the ability to underage various aluminum-lithium alloys to a predetermined strength while enhancing fracture toughness. And certainly nothing in the record suggests that other inventors produced alternatives to the patented claims. Accordingly, while this factor does not play a substantial role in the court's analysis, it tends to support, albeit slightly, the conclusion that the '682 patent was not obvious.

e. Redux

A latent subtext underlies defendant's arguments – that its evidence of obviousness is so compelling that the burden effectively shifted to plaintiff to prove the validity of its patent. But, while there are some similarities between claims 1 and 7 and the prior art, there are more glaring

distinctions, the foremost of which is the absence of any "predetermined" strength level. And, critically, there is no concrete indication that one skilled in the art would have known to combine the various features of other prior art to derive claims equivalent to the '682 patent. That the teachings of these various references may be bent and cobbled together to produce an invention similar to claims 1 and 7 of the '682 is not enough, as it beyond cavil that "[v]irtually all inventions are combinations and virtually all are combinations of old elements." *Environmental Designs, Ltd. v. Union Oil Co. of Cal.*, 713 F.2d 693, 698 (Fed. Cir. 1983), *cert. denied*, 464 U.S. 1043 (1984). Having concluded that claim 1 is not obvious, it follows, *a fortiori*, that dependent claim 7 is also not obvious. Hence, the court finds that defendant has fallen well short of proving that any of the claims in the '682 patent are obvious.

3. Terminal Disclaimer

One last potential basis for invalidity must be considered – the possibility that plaintiff has disclaimed the '682 patent for the latter portion of the period at issue.

Double patenting – obtaining more than one patent on the same invention – is prevented by 35 U.S.C. § 101. *See In re Longi*, 759 F.2d 887, 892 (Fed. Cir. 1985). The courts have interpreted this statute as also "preclud[ing] a second patent on an invention which 'would have been obvious from the subject matter of the claims in the first patent, in light of the prior art.'" *Ortho Pharm. Corp. v. Smith*, 959 F.2d 936, 940 (Fed. Cir. 1992) (quoting *In re Longi*, 759 F.2d at 893). This concept of obviousness-type double patenting is used to prevent a patent holder from improperly extending the protection for an earlier patented invention by obtaining a new patent on a derivative invention. *Id.* (citing *In re Braat*, 937 F.2d 589, 592 (Fed. Cir. 1991)). A patentee can overcome this prohibition by using a terminal disclaimer, that is, disclaiming the portion of patent protection for the second patent that would extend beyond the expiration of the first. *Id.*; *see also Geneva Pharm., Inc. v. Glaxomithkline, PLC*, 349 F.3d 1373, 1377-78 (Fed. Cir. 2003); *Ortho Pharmaceutical*, 959 F.2d at 940 ("By disclaiming that portion of the second patent which would extend beyond the expiration of the first, the patentee gives up any extension of patent protection that might have resulted.").

In this case, Boeing filed a terminal disclaimer on April 19, 1989, that disclaimed "the terminal part [of the '682 Patent] which would extend beyond the expiration dates of Patent No. 4,603,029 and Patent No. 4,735,774, and hereby agrees that [the '682 Patent] shall be enforceable only for and during such period that the legal title of said patent shall be the same as legal title to United States Patents No. 4,603,029 and No. 4,735,774." The language used in the disclaimer was taken from the Manual of Patent Examining Procedure (MPEP) § 1490 Form 3.53 – Terminal Disclaimer to Obviate a Double Patenting Rejection, the only form then provided for such purpose. That version of the MPEP somewhat cryptically instructed the patentee to "[s]ee MPEP § 1490 for wording for a terminal disclaimer. In drafting the terminal disclaimer, consideration should be given to the effect on the expiration date of one patent if a maintenance fee is not paid on the other patent." MPEP § 804.02 (5^{th} ed., Rev. 8, 1988).

Based upon Boeing's disclaimer, defendant contends that there can be no infringement in this case after April 10, 1996, the expiration date of the earlier-to-expire of the two patents to which the '682 patent was linked in the terminal disclaimer. As the standard form that Boeing used did not make an explicit exception for early expiration of the prior patent due to failure to pay maintenance fees or otherwise, defendant contends that the "plain language" of the disclaimer caused the '682 patent to lapse on April 10, 1996. Plaintiff counters that the reference to "expiration dates" in its terminal disclaimer refers not to the actual date that those patents expired for the nonpayment of maintenance fees, but rather to the dates corresponding to the full statutory terms of the earlier patents.

"A terminal disclaimer ties the affected patents together; they expire on the same date and are enforceable only during periods in which they are owned by the same person." Donald S. Chisum, 3A Chisum on Patents, § 9.04[5] at 9-115 (2005); *see also In re Van Ornum*, 686 F.2d 937, 939, 944 (C.C.P.A. 1982). However, the continued validity of the affected patents does not, by virtue of the disclaimer, become completely intertwined. For example, the Federal Circuit recently held that the filing of a disclaimer did not tie the validity of two patents together so that inequitable conduct invalidating one of them would also invalidate the other. *Pharmacia Corp. v. Par Pharm., Inc.*, 417 F.3d 1369, 1374 (Fed. Cir. 2005) (internal citations omitted). In so concluding, the Federal Circuit reasoned –

> Strong policies dictated the judicial creation of [the terminal disclaimer] doctrine governing the co-expiration and co-ownership of sufficiently related patents. Beyond their shared expiration date, however, two disclaimed patents maintain significant attributes of individuality. . . . If [a patentee] does not pay the maintenance fee on one of the patents, that oversight would have no effect on the validity or enforceability of the other patent. This individuality between terminally disclaimed patents indicates something more than a naked terminal disclaimer is required.

Pharmacia Corp., 417 F.3d at 1374. Other cases also have stressed the individuality of patents in limiting the impact of disclaimers. S*ee Ortho Pharm. Corp. v. Smith*, 18 U.S.P.Q. 2d (BNA) 1977, 1982 (E.D. Pa. 1990), *aff'd*, 959 F.2d 936 (Fed. Cir. 1992) ("terminal disclaimer . . . merely fixes an earlier date certain upon which that patent expires. . . . [T]he disclaimer does not operate to tie the validity of [the later issued patent] to the validity of [the earlier issued patent] or any other patent."). Defendant, however, notes that the current disclaimer form in the MPEP, like the form at issue in *Pharmacia*, explicitly states that if the prior patent expires for failure to pay a maintenance fee, or is in any manner terminated prior to the expiration of its full statutory term as presently shortened by any terminal disclaimer, the patent subject to the terminal disclaimer is not similarly shortened. *See* PTO Form PTO/SB/26 (Sep. 2004). Such, of course, is not the case here. But, careful review of the *Pharmacia* decision reveals that its rationale was not so cramped as to depend entirely upon the language of the disclaimer at issue there. As that case suggests, there are, indeed, independent reasons for concluding that the disclaimer here did not invalidate the '682 patent after the earlier referenced patents terminated.

Contrary to defendant's assertions, the meaning of the term "expiration date," as used in Boeing's terminal disclaimer, is far from plain. As the Supreme Court indicated in construing the same phrase found in a provision of the National Labor Relations Act, the term "'[e]xpiration' has no . . . fixed and settled meaning." *NLRB v. Lion Oil Co.*, 352 U.S. 282, 290 (1957). Consistent with this view, one well-known lexicon defines the term as referring both to an actual termination date, *i.e.*, "[t]he date on which something is no longer valid or in effect," and to an expected termination date, *i.e.*, "[t]he date past which a product . . . is no longer expected to be . . . effective." The American Heritage Dictionary of the English Language 625 (4th ed. 2000).[31] Tracking this definition, the question here, of course, is whether the term "expiration date," as used in the terminal disclaimer, was intended to refer to the date that the referenced patents actually expired or rather to the date that they were expected to expire. Absent clear language, this court must look elsewhere in properly divining which definition of the phrase "expiration date" to adopt.

Several considerations appear to hold sway in this regard. First, the '682 patent, even though modified by a terminal disclaimer, is still presumed valid under 35 U.S.C. § 282. *See Pharmacia*, 417 F.3d at 1374. This would suggest that, all other factors being equal, ambiguities in the disclaimer should be construed in favor of validity. As such, it makes particular sense to interpret the disclaimer in terms of its limited purpose, namely, to avoid a rejection based on obviousness of the same invention which would have the effect of extending the patent monopoly beyond the expiration date of the earlier patent. *In re Kaplan*, 789 F.2d 1574, 1579-80 (Fed. Cir. 1986). To avoid such double-patenting, Boeing needed to disclaim only the portion of the '682 patent's term that would have exceeded the statutory term of its prior patents – it did not need to make the term of the '682 patent strictly dependent upon whether maintenance fees were paid on the latter patents. Construing the disclaimer in this fashion tracks how the Federal Circuit generally has construed statements made by inventors in prosecution histories, particularly in the context of estoppel claims. In that context, that court has opined that it will consider "the purpose of the statements made to the PTO," *Insituform Tech., Inc. v. Cat Contracting, Inc*., 99 F.3d 1098, 1107 n.8 (Fed. Cir. 1996), *cert. denied*, 520 U.S. 1198 (1997), as well as what "a competitor, reading the prosecution history, would reasonably conclude was given up by the applicant." *Id*. at 1107-08.[32] In the case *sub judice*, it is reasonable to conclude that a competitor, viewing the prosecution history, and with a particular eye toward what was

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[31] *See also* V The Oxford English Dictionary 568 (2d ed. 1989) ("The fact of coming to an end; termination, end, close: a. of a period of time, or of something made to last a certain time, as a law, truce, *etc*.").

[32] *See also Mark I Mktg. Corp. v. R.R. Donnelly & Sons Co.*, 66 F.3d 285, 291 (Fed. Cir. 1995), *cert. denied*, 516 U.S. 1115 (1996); *Haynes Int' l Inc. v. Jessop Steel Co.*, 8 F.3d 1573, 1578 (Fed. Cir. 1993) ("The legal standard for determining what subject matter was relinquished is an objective one, measured from the vantage point of what a competitor was reasonably entitled to conclude, from the prosecution history, that the applicant gave up to procure issuance of the patent.").

necessary to avoid double patenting, would not have read the disclaimer in the broad fashion defendant contends. Defendant has provided not a stitch of evidence to the contrary – indeed, it all but ignored this assertion until closing arguments.

Viewing the disclaimer as referring to the full statutory term of the earlier cited patents also finds support in the Federal Circuit's decision in *Bayer AG v. Carlsbad Tech., Inc.*, 298 F.3d 1377 (Fed. Cir. 2002). In *Bayer*, the patentee countered an allegation of double patenting by filing a terminal disclaimer in which it disclaimed the terminal portion of the subject patent "which extends beyond October 01, 2002, the earlier of the expiration dates [of two existing patents]." *Bayer*, 298 F.3d at 1380. The April 21, 1992, issue of the PTO's Official Gazette carried a notice of the disclaimer stating: "The term of this patent subsequent to October 1, 2002, has been disclaimed." *Id*. at 1378. Then, in 1994, Congress passed the Uruguay Round Agreements Act (URAA), Pub. L. No. 103-465, 108 Stat. 4809 (1994), one provision of which harmonized U.S. patent law with that of other nations by changing the patent term from seventeen years from the date the patent was granted, to twenty years from the filing of the application. *Id.* at 1378; *see* 35 U.S.C. § 154(a)(2), (c)(1). In 1995, Bayer sought to amend its disclaimer to make clear that the URAA had extended the term of its patent from October 1, 2002, to December 9, 2003 (20 years after the application). *Bayer*, 298 F.3d at 1379. The PTO denied the request, but amended its records to reflect the extended term of the patent under the URAA. In 2001, a dispute arose regarding the effect of the original disclaimer, which was resolved when a district court upheld the PTO's interpretation of the impact of the URAA. *Id.*

On appeal, the Federal Circuit affirmed. It noted, as had the PTO, that the passage of the URAA had created a patent ambiguity in the disclaimer – when filed, the document disclaimed the term "beyond October 1, 2002," then referenced as the "earlier of the expiration dates" of the two subject patents, but after the passage of the URAA, the earlier of the expiration dates no longer coincided with October 1, 2002, but rather was December 9, 2003. *Id*. at 1380-81. The court of appeals ruled that the district court had properly upheld the PTO's view that the term of the subject patent had been extended "by operation of law" and that the resolution of the ambiguity in the disclaimer should give effect to this change. *Id*. at 1381. Rejecting the notion that the ambiguity instead should be resolved, as Carlsbad termed it, "in favor of the public," that is, giving effect to the expressed date of "October 1, 2002," the Federal Circuit instead held that the disclaimer should be construed "in context," that is, with an eye toward the fact that it had been filed to "defend against [the] allegation that the [subject] patent was invalid for double patenting over the two [earlier] patents." *Id*. at 1382. It thus found that, consistent with this purpose, the date the earlier patents would actually expire, *i.e.*, December 9, 2003, should control, as that was all the public could expect in avoiding the double patenting that otherwise would have resulted. *Id*. at 1382-83.

As was true in *Bayer*, Boeing's terminal disclaimer here must be interpreted "in context." To escape problems with double patenting, Boeing simply ensured that the '682 patent would not extend past the statutory termination date of the earlier patents – that is what one would have objectively understood at the time the disclaimer was filed. Defendant has provided no basis for construing the phrase "expiration date" otherwise, in the face of later events. Indeed, it points to

no case that has remotely construed a disclaimer in the fashion it argued – certainly, nothing in *Pharmacia* would support such a conclusion. Accordingly, the court concludes that the early expiration of Boeing's earlier patents due to its choice not to pay the maintenance fees does not affect the expiration date of the full statutory term to which these earlier patents originally were entitled, and to which, and only which, the '682 patent was tied.

C. Infringement

Boeing has the burden of proving infringement by a preponderance of the evidence. *Centricut, LLC v. Esab Group, Inc.*, 390 F.3d 1361, 1367 (Fed. Cir. 2004), *cert. denied*, 126 S.Ct. 337 (2005); *Seal-Flex, Inc. v. Athletic Track and Court Constr.*, 172 F.3d 836, 842 (Fed. Cir. 1999). Defendant argues that plaintiff has not met this burden because it did not show that Alloy 2195, which has a silver content of 0.25 to 0.6 wt %, met the composition limits of the patent. Defendant also argues that various components of the external tank do not meet other limits of the patent, owing to differences in alloy composition and aging.

Determining whether a patent has been infringed is a two-step process. *Terlep v. Brinkmann Corp.*, 418 F.3d 1379, 1381-82 (Fed. Cir. 2005); *Jeneric/Pentron, Inc. v. Dillon Co.*, 205 F.3d 1377, 1380 (Fed. Cir. 2000). First, the court must construe the claims, as a matter of law. *JVW Enter., Inc. v. Interact Accessories, Inc.*, 424 F.3d 1324, 1329 (Fed. Cir. 2005). Second, "the fact finder compares the properly construed claims to the accused device or process." *Catalina Mktg. Int'l Inc. v. Coolsavings.com, Inc*., 289 F.3d 801, 812 (Fed. Cir. 2002) *(citing Cybor Corp.*, 138 F.3d at 1454); *see also JVW Enter.*, 424 F.3d at 1333; *Aquatex Indus., Inc. v. Techniche Solutions*, 419 F.3d 1374, 1380 (Fed. Cir. 2005). "[E]ach element of a claim is material and essential, and . . . in order for a court to find infringement, the plaintiff must show the presence of every element [for literal infringement] or its substantial equivalent [for infringement under the doctrine of equivalents] in the accused device." *Lemelson v. United States*, 752 F.2d 1538, 1551 (Fed. Cir. 1985); *see also Rohm & Haas, Co. v. Brotech Corp.*, 127 F.3d 1089, 1092 (Fed. Cir. 1997).

1. The Addition of Silver

Where, as is true in claim 1, the transition term "consisting essentially of" is employed, the claim is partially open and "interpreted according to [the Federal Circuit's] decision in *PPG Indus. v. Guardian Indus. Corp.*, 156 F.3d 1351 (Fed. Cir. 1998)." *W.E. Hall Co. v. Atlanta Corrugating, LLC*, 370 F.3d 1343, 1353 (Fed. Cir. 2004). The "consisting essentially of" language "permits infringement by products with immaterial elements in addition to the elements already required by the claim." *Id.* (emphasis omitted). In other words, the invention is "open to unlisted ingredients that do not materially affect the basic and novel properties of the invention." *PPG Indus.*, 156 F.3d at 1354; *see also Atlas Powder Co. v. E.I. du Pont De Nemours & Co.*, 750 F.2d 1569, 1574 (Fed. Cir. 1984) (internal citations omitted) ("excludes ingredients that would materially affect the basic and novel characteristics of the claimed composition"); *Application of Janakirama-Rao*, 317 F.2d 951, 954 (C.C.P.A. 1963). Accordingly, the question here is whether

the intentional addition of silver as an alloying agent in Alloy 2195 materially affects the "basic and novel" properties of the invention in the '682 patent.

Not surprisingly, the Federal Circuit has taught that to identify the "basic and novel" properties, this court should look to the patent and its specification. *AK Steel Corp. v. Sollac & Ugine*, 344 F.3d 1234, 1239-40 (Fed. Cir. 2003); *PPG Indus*., 156 F.3d at 1355. Various parts of the '682 patent highlight that its basic and novel property is to improve the fracture toughness of aluminum-lithium alloys without reducing the strength of the alloy. Thus, the summary of the invention indicated that it "provides a method for aging aluminum-lithium alloys of various compositions at relatively low temperatures to develop a high and improved fracture toughness without reducing the strength of the alloy." These characteristics are reemphasized in the introduction to claim 1, which refers to a "process for improving the fracture toughness of an aluminum-lithium alloy without detracting from the strength of said alloy."

These basic and novel characteristics were confirmed by both experts, with Dr. Hunt emphasizing that, prior to the patent, one had to yield strength in order to improve fracture toughness. Dr. Hunt also convincingly testified that the addition of silver did not alter the basic and novel characteristics of the invention. Using effective slides and video presentations, he described, in great detail, the metallurgical principles underlying the patent, explaining that the benefits obtained thereunder related to the increased precipitation of strengthening precipitates on the grains (space-filling units) constituting the aluminum-lithium alloy, as well as reductions in grain boundary precipitates and precipitate free zones, both of which serve as fracture zones in aluminum-lithium alloys. Relying, in part, on two papers that studied the process of the '682 patent, one of which involved an aluminum-lithium alloy with silver, Dr. Hunt testified that the addition of silver did not alter the metallurgical principles at work in the patent's process –

> the mechanism by which the low-temperature underaging process improves the fracture toughness is the same in alloys with silver or without silver . . . . And that particular mechanism relates to the reduction in grain boundary precipitates and the minimization of precipitate-free zones that can be achieved through using low-temperature underaging.

He concluded –

> My conclusion is that silver does not affect the basic and novel characteristics of the invention that's disclosed in the '682 patent. And that is because we see the same benefits in terms of improved fracture toughness without reducing strength through low-temperature underaging in alloys with silver and in alloys without silver. We see the same mechanisms that are giving rise to the improvement: the reduction in grain boundary precipitates, the minimization of precipitate-free zones.

In relevant part, these views were not contested by Dr. Starke, who agreed that "the addition of silver . . . doesn't change the basic principles or the effect of low temperature aging," and that the

application of the patent to an aluminum-lithium alloy would still lead to fracture toughness being improved without any significant reduction in strength.

Dr. Starke disagreed with Dr. Hunt not on whether the addition of silver altered the basic and novel characteristics of the invention, but rather on whether that addition improved one or more features of the resulting alloy. However, the latter is not the question here, unless the alleged improvements derived from some modification of the basic and novel characteristics of the patent, of which there was no indication in Dr. Starke's testimony.[33] Even if Alloy 2195 were superior in all ways to the alloys processed solely under the patent, defendant could still be liable for infringement as it is well-accepted that one cannot avoid infringement by building upon a prior patent. "It is fundamental," the Federal Circuit has stated, "that one cannot avoid infringement merely by adding elements if each element recited in the claims is found in the accused device." *A.B. Dick Co. v. Burroughs Corp.*, 713 F.2d 700, 703 (Fed. Cir. 1983), *cert. denied*, 464 U.S. 1042 (1984); *see also Stiftung v. Renishaw PLC*, 945 F.2d 1173, 1178 (Fed. Cir. 1991). This is because infringement does not require "that a claim read on the entirety of an accused device," but merely "on a part" thereof. *Suntiger, Inc. v. Scientific Research Funding Group*, 189 F.3d 1327, 1336 (Fed. Cir. 1999); *see also N. Telecom.*, 908 F.2d at 945 ("The addition of features does not avoid infringement, if all the elements of the patent claims have been adopted."). "Any other reasoning would allow an infringer to avoid infringement merely by adding additional elements to an infringing device." *Suntiger*, 189 F.3d at 1336.[34]

The court perceives no reason why these principles ought not apply to metallurgy. Consequently, if an alloy reads on all the elements of the patent, it will infringe even if it results in alloys better than those produced under the process of the patent. The issue rather is whether the addition of silver to the 2195 Alloy prevents the elements of the patent claims from being

[33] Dr. Starke did testify that the addition of silver sped up the kinetics of the process, but he never indicated whether this constituted a significant modification of the basic and novel characteristics of the invention.

[34] *See also JVW Enter.,* 424 F.3d at 1333 ("additional features amount to improvements that do not avoid infringement"); *Wallace Bus. Forms, Inc. v. UARCO Inc.*, 231 U.S.P.Q. 216, 220 (N.D. Ill. 1986), *aff'd*, 824 F.2d 977 (Fed. Cir. 1987) ("Infringement cannot be avoided by adding features or making improvements while, at bottom, utilizing the basic concept at the heart of the patent."); 5A Chisum on Patents § 18.03[4][b][ii] at 18-350. This rule is of ancient lineage. *See Hoyt v. Horne*, 145 U.S. 302, 309 (1892) ("defendant's engine may be in this particular an improvement upon the other; but he has none the less succeeded in appropriating all that was of value in the [patented] device"); *Cochrane v. Deener*, 94 U.S. 780, 787 (1876) ("One invention may include within it many others, and each and all may be valid at the same time. This only consequence follows: that each inventor is precluded from using inventions made and patented prior to his own, except by license from the owners thereof. His invention and his patent are equally entitled to protection from infringement, as if they were independent of any connection with them.").

met. And the record evidence resoundingly answers – no, it does not. The court finds, based upon weighty evidence, that even with the addition of silver, the aging process in the patent still positively affects the microstructure of the alloys, producing a significant increase in fracture toughness without degrading the strength of an aluminum-lithium alloy through low temperature aging. Accordingly, the addition of silver does not avoid infringement.[35]

2. Aging temperature

Defendant also contends that components of the external tank aged at 300° F do not infringe the '682 patent, which claims an aging range of "from about 200° F. to less than 300° F." Specifically, it argues the LH_2 barrel panels do not meet the asserted claims because they were aged at an oven setting of 300° F. Plaintiff strongly contests the notion that the 300° F alleged oven setting represents the aging temperature of the panels, noting that testimony from the quality assurance manager of the company that aged the panels, AMRO, refers to the aging temperature as a plus or minus range centered on 300° F, that is, 300° F ± [ ]°. Moreover, it points out that AMRO's heat treatment verification reports for the subject barrel panels indicate that the desired heat setting was "300 ± [ ] deg F." Indeed, some of these reports provide furnace data for certain relevant time periods that indicate that the actual temperature of the furnace at an apparent 300° F setting ranged from a low of [ ]° F to a high of [ ]° F. Perhaps cognizant of this, the operating instructions for aging the barrel panels indicated that each part aged must have [ ] attached during the aging cycle and that the reading on those [ ] had to be within ± [ ] degrees of the stated temperature on the certificate of compliance. Yet other evidence, in particular, a video summarizing [ ] readings during the aging of one barrel panel, reveals that, during the aging process, several portions of the barrel panel never attained a temperature of 300° F, while at least some of the surface of the panel remained below 300° F for ten or more hours during the approximate [ ]-hour aging process.

The record thus indicates that, at least as to the barrel panels examined to date, a significant portion – in some cases, all – of the aging process occurred at below 300° F. Moreover, this court has rejected, as a matter of construction, defendant's assertion that the temperature range listed in claim 1 of the '682 patent refers to the commercial oven setting. The treatment received by the barrel panels verifies the correctness of this ruling – were defendant correct, an intrepid manufacturing could avoid infringement simply by using an ill-calibrated oven, knowing, full well, that aging was actually occurring at a temperature below the oven setting. This court, however, has found that the temperature range listed in claim 1 of the patent refers to the actual temperature at which significant underaging is occurring. Therefore, to the extent that the barrel panels were actually aged for a significant period of time at a temperature

[35] It should be noted that, in arguing that the silver content in Alloy 2195 precludes a finding of infringement, defendant asserts that silver is a "trace element" within the meaning of the '682 patent. This court, however, has ruled that the phrase "trace element" refers to undesired impurities and thus does not include elements purposely added to the alloy. As such, silver clearly does not qualify as a "trace element" within the meaning of the patent.

below 300° F, they, to the extent they meet the other elements of the relevant claims, infringe upon the patent.

3. Do the parts of the external tank infringe the '682 patent?

Alloy 2195 is used in both the LO_2 and LH_2 tanks of the SLWT. At trial, plaintiff chose to read claim 1 of the '682 patent on one part from the LO_2 tank and one part from the LH_2 tank. Plaintiff has reserved the right to demonstrate, as part of the damages portion of this case, that the remaining parts of the LO_2 and LH_2 tanks that were fabricated from Alloy 2195 were processed in the same manner as the two parts addressed at the trial.

At the trial, Dr. Hunt demonstrated, via claim charts and associated testimony, that every element of claims 1 and 7 of the patent could be found in the parts of the LO_2 and LH_2 tanks examined – the aging temperature and time for these parts fell within the patent's ranges; the parts were solution heat treated and quenched; the panels were aged to a predetermined underaged strength level; and, with the exception of silver, the chemical composition of the alloy used to fabricate these parts fell within the range of the chemical composition in claim 1. Based on his analysis, Dr. Hunt opined that the panels in question infringed claim 1 of the '682 patent and that the SLWT infringed claim 7 of the patent. Defendant's arguments to the contrary hinged upon its assertions regarding the use of silver and temperature, rejected above. Accordingly, the evidence in question preponderates in favor of a finding that the SLWT of the Shuttle is comprised of an alloy that, barring a license, infringes the '682 patent.[36] It remains to determine whether defendant had such a license, an issue to which the court now turns.

D. License

Defendant lastly asseverates that, under the Patents Right Clause of the 5053 contract, it acquired a license to use the invention represented by the '682 patent because that invention was discovered "during" the course of the 5053 contract. This argument, however, conveniently overlooks the actual language of the relevant clause.

Recall that the 5053 contract between Boeing and the Air Force was executed in late 1981 and became effective on January 4, 1982. This was approximately during the time that the '682 patent was being developed by Boeing. Contrary to defendant's characterization, however, the Patents Rights Clause did not apply to inventions discovered "during" the time that the 5053 contract was being performed, but applied only to inventions "conceived or first actually reduced to practice in the course of or under" the contract. In another subdivision, the clause emphasized that the government could not otherwise obtain the rights with respect to any invention not conceived or actually reduced to practice "in the course of or under" the contract. In fact, the

[36] Defendant contends that the lithium content in certain versions of Alloy 2195 used in the SLWT exceeded the parameters of the patent. In the court's view, this issue requires further ventilation and should be reserved for the damages phase of this case.

same clause indicated that if Boeing failed to disclose an invention conceived or first actually reduced to practice "in the course of or under" the contract, the United States would obtain not only a license to such an invention, but the invention itself. Accordingly, if the '682 patent were "conceived or first actually reduced to practice in the course of or under" the 5053 contract, the fact that the invention was not disclosed – which it was not – would result in the United States owning the invention represented by the patent.

Defendant has the burden of demonstrating that conception or first actual reduction to practice of the subject invention occurred "in the course of or under" the 5053 contract. To meet that burden, it "must do more than broadly allude to various connections or contracts between an invention and a Government contract," and "must supply hard facts to support its position." *Tech. Dev. Corp. v. United States*, 597 F.2d 733, 746 (Ct. Cl. 1979). Here, defendant has not come close to meeting its burden. To be sure, two of its witnesses testified that the teaching of the '682 patent was developed during the period corresponding to the 5053 contract. They also pointed to indications in the interim status reports filed under the 5053 contract (particularly, the third such report) that at least some of the teachings of the patent may have been practiced in the development of aluminum-lithium alloys under the contract. But, each of these witnesses abruptly retreated when asked the critical question whether the '682 patent was conceived or actually reduced to practice "in the course of or under" the contract, essentially indicating that they had no reason to dispute that the '682 patent was developed by Boeing as part of its separate IR&D program. For example, Mr. Ronald, the Air Force's project engineer for the 5053 contract, testified –

> Q: Do you dispute Boeing's contention that it did the work to conceive the patent and reduce it to practice under its IR&D program?
>
> A: No.
>
> *　　*　　*　　*
>
> Q: Do you have any factual basis at the hearing today, to assert that Boeing did not pay entirely for the invention set forth in patent '682?
>
> A: No, I don't.
>
> *　　*　　*　　*
>
> Q: Do you have any factual basis, sitting here today, to assert that anything done under Contract 5053 led in any way to the invention of patent '682, in any possible way?
>
> A: . . . I have no factual basis.

Dr. Starke's testimony was to similar effect. Mr. Ronald, in fact, went on to acknowledge that the aging treatments employed by Boeing in the 5053 contract came from its experience under its own IR&D program, a concession consistent, *inter alia*, with his prior approval of various reports filed by Boeing during the administration of the 5053 contract indicating that no inventions had been developed under the contract.

Were this not enough, as part of its case in chief, Boeing presented convincing testimony that the key elements of the '682 patent had been developed and reduced to practice before the operational phase of the 5053 contract began. For example, while defendant asserts that the invention was revealed in the aging and testing of "alloy 11" that occurred in March of 1983 and was recorded in the third interim report, the record reveals that the aging processes defendant cites were actually reduced by Boeing to practice in mid-1982 as part of its IR&D program. Indeed, it appears that the 5053 contract was so underfunded that little or no independent development of aging processes occurred thereunder. Thus, Dr. Narayanan testified, without contravention, that, owing to the low level of funding in the 5053 contract, the methodologies employed by Boeing and its subcontractors during the contract were either developed in the IR&D program at Boeing's expense or otherwise came from the companies' prior experience. According to Dr. Narayanan, this approach was consistent with Boeing's proposal under the contract –

> In our proposal, we . . . suggested that heat treatments would be selected on the basis of our prior experience, survey of literature, and consultation with other partners. And we were not required or we had not agreed to conduct extensive aging studies at multiple temperatures to select heat treatments.

Dr. Narayanan emphasized that the contract did not focus on ingot alloy development whatsoever, except as a baseline for comparison to the powder metallurgy that was the principal focus thereof.

Accordingly, there is no evidence that the invention represented by the '682 patent was "conceived or first actually reduced to practice in the course of or under" the 5053 contract. Defendant's speculation on this count falls victim to its lack of proof. Therefore, defendant did not acquire a license to practice the '682 patent.[37]

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[37] To be sure, a major purpose of patent clauses is to ensure that the government does not have to pay a second time for a patent it helped to develop. As stated by the Court of Claims in *Tech. Dev.*, 597 F.2d at 745 –

> Inventions made under a Government contract are the product of expenditures from the public treasury in the course of a governmental function; the public, having in a sense ordered and paid for the invention through its representatives, should not again be taxed for its use, nor excluded from its use, nor permitted to use it upon restrictive conditions advantageous to no one but the patent owner.

III. CONCLUSION

At last, this court need go no further. Based on the foregoing, it finds that the '682 patent is valid, that defendant had no license to practice that patent, and that defendant's use of the '682 patent in constructing the external tank of the Space Shuttle constituted infringement. By way of further provisions –

1. It is the court's intention to unseal and publish this opinion after January 17, 2006. On or before January 16, 2006, each party shall file proposed redactions to this opinion, with specific reasons therefor.

2. On or before January 23, 2006, the parties shall file a joint status report indicating how the damages portion of this case should proceed, with a proposed schedule. Prior to this date, the parties shall, on at least one occasion, engage in settlement discussions, and shall report on the results of those discussions in the joint status report.

IT IS SO ORDERED.

s/ Francis M. Allegra
Francis M. Allegra
Judge

> *Mine Safety Appliances Co. v. United States*, 364 F.2d [at] 392 . . . (quoting Investigation of Government Patent Practices and Policies, Report and Recommendations of the Attorney General to the President, Vol. I, pp. 88-89 (1947)).

At the same point, such clauses should not be twisted as to require so little evidence of a nexus between the contract and an invention as to confer a windfall – and, in the court's view, that is exactly what defendant seeks here.